

Chapter 9

Integrated Design of Generative Relational Research

Chapter 9 develops the integrated design architecture of Generative Relational research. Its role within Part III is to coordinate the research-practical, relational, generative, evidential, formal, computational, ethical, and documentary resources developed across the preceding chapters into a project-level structure. Chapter 6 established research-dominant praxis as a historically situated and relationally organized form of activity in which encounter, attention, judgment, methodological plurality, reflexivity, revision, and preservation shape what becomes knowable. Chapter 7 developed methods for identifying, reconstructing, characterizing, measuring, interpreting, validating, and reporting relations. Chapter 8 developed the stronger methodological architecture required for generative claims concerning mechanisms, trajectories, sequence, counterfactuals, co-generation, delay, propagation, feedback, structural transformation, capacities, constraints, option spaces, changing generative rules, multiscale processes, formal representations, simulations, interventions, attribution, robustness, and reporting. The present chapter asks how those components should be organized when the unit of analysis is an entire research project rather than a single relation, method, model, or claim.

Integrated design is required because research components constrain one another. A research question can be more specific than the available evidence permits. A formal representation can require distinctions that the data do not preserve. A case-selection strategy can narrow the scope of inference. A change in ontological position can alter which observations count as evidence. A historical reconstruction can reveal that a category used in measurement changed meaning across the study period. A simulation can expose a missing mechanism and motivate new fieldwork. An ethical constraint can alter the feasible intervention and thereby change the evidential architecture. A robustness failure can require a narrower claim, a different representation, or a revised research question. The design problem therefore concerns the coordination of dependencies across the project rather than the independent selection of individually competent methods.

The chapter uses the term *architecture* to emphasize inspectable relations among project components. An architecture specifies which elements depend on which others, where translation occurs, where uncertainty enters, which decisions are provi-

sional, and how revisions propagate. It differs from a checklist. A project can satisfy a list of procedural requirements while remaining internally incoherent if its object, data, methods, representation, and inferential claims are poorly aligned. Conversely, a comparatively simple project can be methodologically strong when its components are proportionate to the question and their connections are explicit. Integrated design therefore concerns coherence, adequacy, provenance, and revisability rather than maximal procedural complexity.

The starting point precedes formal question specification. Research frequently begins with an encounter: an anomaly, difference, unexpected relation, historical rupture, recurrent pattern, conceptual tension, practical difficulty, or contingent observation. Such an encounter can become salient without yet having established significance. Research judgment then mediates among epistemic, theoretical, practical, aesthetic, and normative considerations. Problem formation and question formation convert this provisional orientation into a researchable structure. Chapter 9 preserves this pre-question history because the path through which a question emerges can affect what is selected, excluded, measured, formalized, and treated as worth explaining. Integrated design therefore records the formation of inquiry rather than presenting the finalized question as though it appeared without a history.

The chapter also preserves ontological suspension. A research project requires sufficient commitment to construct objects, boundaries, relations, categories, and representations, yet those commitments need not become final ontological declarations. An entity can be represented as an actor in one model, a node in another, a bundle of capacities in a third, and an institutionally classified object in a fourth. The design should state which ontological position is operationally required, how that position shapes evidence, and what alternative descriptions remain plausible. Ontological choice thereby becomes part of the architecture of inference rather than a hidden background assumption.

Epistemic claims require comparable explicitness. A project may aim to describe, reconstruct, interpret, estimate, compare, attribute, explain, simulate, evaluate, or normatively assess. These operations have different evidential requirements. A project that claims existence or association requires a different architecture from one that claims a generative mechanism, a transformation of a generative rule, or a normative conclusion. The intended epistemic claim should therefore constrain methodological strategy and evidence architecture early enough to prevent later inflation of inference. At the same time, the design must allow the claim to change when the inquiry reveals that its initial level of ambition is poorly supported.

Methodological plurality enters at the project level through deliberate portfolios and sequences. Historical, interpretive, qualitative, quantitative, formal, computational, and intervention-based methods provide partially irreducible forms of access. Integrated design asks which method should be primary for a given component, which methods can supply complementary evidence, where methodological redundancy is valuable, how methods should be sequenced, and how disagreement among their outputs should be adjudicated. Breadth itself carries no presumption of superiority. The relevant criterion is whether the portfolio preserves the distinctions required by the question while remaining proportionate to available evidence, resources, ethical obligations, and inferential goals.

Evidence architecture receives corresponding emphasis. Data are not interchangeable merely because they can be placed in the same dataset or model. Archival documents, interviews, administrative records, observations, measurements, relational traces, simulated outputs, intervention-generated evidence, and AI-assisted classifications can bear on different components of a claim. The project should state which evidence supports object identification, relational reconstruction, sequence, mechanism, counterfactual comparison, structural transformation, scale transition, or robustness. Provenance should remain attached to those evidential roles. This permits later reinterpretation when categories, methods, or theoretical commitments change.

Representation forms a further layer of design. A narrative, table, graph, geometry, field, algebraic structure, dynamical system, spacetime reconstruction, agent-based model, or partially ordered generative trajectory complex preserves some differences while compressing others. Chapter 8 developed several of these representations in methodological detail. Chapter 9 asks how a project should choose among them, combine them, translate across them, and document the losses introduced by each translation. A representation becomes methodologically useful when its preserved distinctions correspond to the research question and when its abstractions remain legible to the evidence from which they were constructed.

The design must also remain historical. Research objects, categories, data infrastructures, methods, evidential standards, institutions, and normative expectations change. A project that spans time can therefore encounter category drift, changing observability, institutional transformation, and altered relations between data and the phenomena represented. Chapter 9 treats historical re-epistemization as a design requirement: records, alternative models, superseded interpretations, contextual information, and versioned categories should be preserved sufficiently for later researchers to reassess earlier claims under changed knowledge conditions.

AI-assisted research intensifies this requirement. Search, synthesis, coding, formalization, simulation, critique, and candidate theory revision can be accelerated by computational systems. This expansion of exploratory capacity increases the importance of verification, provenance, audit trails, dependency management, and preservation of research judgment. AI outputs can become inputs to research architecture, but their epistemic status depends on how they were generated, checked, connected to evidence, and incorporated into decisions. Chapter 9 therefore includes AI-assisted workflow within the same integrated architecture as data, models, interpretation, and documentation rather than treating it as an external productivity layer.

The chapter proceeds through five broad movements. Sections 239–245 construct the project architecture from encounter and question formation through case, field, data, and representation design. Sections 246–249 organize the method portfolio, sequencing of methods, cross-method adjudication, and recursive dialogue between models and evidence. Sections 250–253 develop sensitivity, robustness, uncertainty, and historical re-epistemization as project-wide architectures. Sections 254–259 address AI-assisted workflow, governance, documentation, reproducibility, reusability, and cumulative research. Sections 260–264 then examine theory development, research decisions, changing uses of models across praxis modes, provisional closure, and completion of the research-dominant praxis block.

The objective is not to prescribe one universal research template. Generative Re-

lational research can take historical, interpretive, empirical, formal, computational, comparative, or intervention-based forms, and many projects will combine only a subset of the methods developed in Chapter 8. The chapter instead specifies a common design discipline: the project should make visible how its question, objects, representations, evidence, methods, inferential bridges, judgments, uncertainty, ethical constraints, documentation, and revision processes are connected. This visibility allows a research project to remain coherent while still changing substantially during inquiry.

A further objective is to preserve research agency under revision. Integrated design should permit a project to change because the evidence warrants change, rather than forcing inquiry to defend its initial plan. New encounters can alter salience. Better evidence can transform the question. A field boundary can prove analytically inappropriate. A representation can conceal a relevant distinction. A formal model can expose a missing mechanism. A counterexample can narrow the claim. An ethical concern can redirect data collection. A generative research architecture therefore includes planned points of reconsideration and records enough of its earlier states to make revision cumulative rather than opaque.

Chapter 9 begins with this project-level architecture. Section 239 follows the formation of a research project from encounter through salience, judgment, problem and question formation, ontological position, epistemic claim, methodological strategy, evidence architecture, and revision planning. The subsequent sections unpack these components and their interactions in greater detail. Section 263 specifies the conditions under which a research cycle can reach provisional closure while preserving uncertainty, alternatives, materials, and conditions for reopening. Section 264 then consolidates the research-dominant praxis block, delimits the competence of research-dominant inquiry, and carries its outputs into application-dominant praxis while preserving the continuing presence of research within later practical action. In this way, Part III completes its movement from research praxis, through relational and generative methodology, toward an integrated and revisable design of inquiry that can enter Part IV without treating research closure as practical or normative closure.

9.1 Architecture of a GR Research Project

This section establishes the project-level architecture that organizes Chapter 9. Its role is to translate the research-practical sequence developed earlier in Part III into an inspectable design structure. The objective is to show how a research project can move from encounter and salience through judgment, problem and question formation, ontological and epistemic commitments, methodological strategy, evidence architecture, and planned revision while preserving the provenance of each transition. The discussion proceeds through these ten components in the order in which they frequently become salient during project formation, while treating the resulting architecture as recursive rather than mechanically linear. The method is conceptual and design-oriented: each component is specified by its function, its dependencies, and the consequences that revision of that component can have elsewhere in the project.

A research project acquires architecture when its major design commitments become mutually legible. The relevant commitments include what drew attention, why the object was judged significant, how the problem was constructed, what questions are being asked, what kinds of objects and relations are provisionally assumed, what epistemic claims are intended, what methods will provide access, what evidence can support each inferential step, and how the design will change when those commitments fail. These components can remain tacit in ordinary research practice. Generative Relational research makes them explicit because relations among design decisions can themselves shape the knowledge that becomes possible.

Definition 9.1 (Integrated GR research-project architecture). An *integrated GR research-project architecture* is the documented and revisable organization of encounter, salience, research judgment, problem formation, question formation, ontological position, epistemic claim, methodological strategy, evidence architecture, and revision planning, together with the dependencies and inferential bridges connecting those components.

Definition 9.1 treats project design as more than a sequence of administrative decisions. The architecture specifies why a method belongs to a question, why a datum bears on a claim, which ontological distinctions a representation presupposes, where uncertainty enters, and what would require revision. The same data and methods can support materially different research projects when these dependencies differ.

The components also have unequal temporal stability. An encounter may remain historically fixed as the origin of inquiry even after its interpretation changes. Salience can decline while the project remains important. A question can be replaced while the underlying problem persists. Ontological assumptions can be revised after new evidence appears. A methodological strategy can change because access conditions shift. Evidence architecture can expand or contract. A revision plan can itself be revised. The architecture should therefore preserve versions rather than forcing every component into one current state.

The project-level perspective also clarifies the relation between design and openness. Explicit architecture does not require premature closure. It provides a structure within which uncertainty, plurality, and revision can remain visible. A project can carry multiple candidate mechanisms, several representations, competing interpretations, or unresolved boundary choices while still documenting which claims each alternative would support. Design becomes a means of organizing openness rather than suppressing it.

9.1.1 Research Encounter

A research project can begin before it possesses a formal problem statement. Chapter 6 developed the research encounter as contact with existence, contingency, difference, anomaly, repetition, unexpected relation, or another phenomenon that becomes available to inquiry. At the project-design level, the relevant task is to preserve enough of that encounter to reconstruct why the subsequent inquiry took the form it did.

An encounter record should distinguish the encountered phenomenon from the interpretation later placed upon it. A researcher may notice that a category is used

differently across institutions, that a relation persists despite an expected change, that two histories diverge after apparently similar conditions, or that a simulation reproduces an empirical pattern through an unexpected mechanism. The first record should preserve what was encountered, where and when it became available, through which instrument or source it was mediated, and which aspects remained uncertain. Later theoretical language can then be added without overwriting the earlier evidential state.

This distinction matters because retrospective knowledge reorganizes memory. Once a mechanism becomes plausible, earlier observations can appear to have pointed toward it from the beginning. Once a finding becomes important, the original encounter can be narrated as though its significance was immediately obvious. Preserving the encounter separately from later interpretation reduces this retrospective compression and permits alternative histories of the research process to remain reconstructable.

Encounter also has conditions of possibility. Access to a field, archive, dataset, language, instrument, community, model, or computational system shapes which phenomena can become encounterable. A research project should therefore record relevant access conditions and mediations. A pattern discovered through an administrative dataset is partly conditioned by the categories through which that institution records the world. An archival encounter depends on survival and organization of records. An AI-assisted encounter with a candidate pattern depends on the corpus, system behavior, prompting context, and verification process. Such conditions belong to the design architecture because they shape the initial evidential horizon.

Proposition 9.2 (Encounter provenance). *A research project becomes more historically reconstructable when the encountered phenomenon, its source or mediation, the conditions of access, and the interpretations subsequently attached to it are recorded as distinguishable components.*

Proposition 9.2 does not require exhaustive autobiographical documentation. The relevant record is proportional to the role of the encounter. An incidental observation that motivates a minor robustness check may require little documentation. An anomalous archive entry or unexpected relation that redirects the entire project should receive correspondingly greater provenance.

9.1.2 Salience

Encounter creates availability for attention; salience organizes which available differences receive sustained notice. At the project level, salience should be treated as an attentional state that influences research allocation without being equated with epistemic significance. The design problem is to record why an encounter became prominent enough to alter the project and to preserve the possibility that important but weakly salient phenomena remain outside immediate attention.

Salience can arise through surprise, contrast, repetition, anomaly, practical urgency, theoretical tension, aesthetic coherence, institutional priority, or technical visibility. These sources can overlap. A sudden discontinuity in a time series may become salient because it is visually striking, statistically unusual, politically important, and theoretically unexpected. The project architecture should distinguish these grounds

where they matter because they create different risks of attentional distortion.

Institutional and infrastructural conditions can strongly shape salience. Available datasets make some questions easier to formulate. Funding priorities amplify certain topics. Disciplinary vocabularies make some differences easier to name. Search systems rank some literatures above others. AI systems can surface patterns according to model-internal and corpus-dependent regularities. A design that records only the researcher's declared interests can therefore miss important sources of salience production.

Salience records are useful because later inquiry can reveal that the initially salient feature was secondary. A striking outcome difference may lead to a deeper structural relation. An anomaly can turn out to be a measurement artifact. A repeated pattern can reflect stable classification rather than stable reality. Conversely, a weakly salient contextual detail can later become the central enabling condition. Integrated design should permit this redistribution of attention without erasing the earlier attentional path.

Definition 9.3 (Design salience record). A *design salience record* identifies the feature that received research attention, the conditions that made it prominent, the provisional reasons for sustaining attention, and the principal alternatives or less-salient features that could plausibly alter interpretation.

Definition 9.3 turns salience into an inspectable part of design. It does not imply that research should distribute attention evenly. It makes selective attention visible enough that later judgment can distinguish prominence from significance.

9.1.3 Research Judgment

Research judgment mediates between salience and organized inquiry. Chapter 6 distinguished epistemic, theoretical, practical, aesthetic, and normative dimensions of judgment. At the project level, judgment determines whether an encountered and salient phenomenon warrants sustained investigation, which aspects deserve priority, what level of uncertainty is acceptable, and how intellectual effort should be allocated.

Integrated design should preserve the criteria through which significance was attributed. A project can be judged worth pursuing because it bears on an unresolved theoretical contradiction, because it opens a new methodological possibility, because it concerns substantial practical consequences, because it reveals neglected historical relations, because it challenges an established category, or because it appears generatively promising despite uncertain immediate utility. These reasons should remain distinguishable from one another. An aesthetically elegant question does not gain evidential support from elegance; a practically urgent problem does not become methodologically tractable merely because delay is costly; a theoretically important problem does not automatically justify intrusive data collection.

Judgment also establishes priority among possible research paths. After an encounter, several questions can be formulated. A project may study existence, relation, historical formation, mechanism, distribution, normative significance, or intervention. The choice among them involves judgment about tractability, evidence, theoret-

ical value, ethical burden, resources, and generative promise. Making these criteria explicit permits later revision when circumstances change.

Research judgment should also preserve conflict. Epistemic and normative judgments can point in different directions. The most informative intervention may impose unacceptable burdens. The most practically urgent question may have weak available evidence. The theoretically elegant model may require assumptions that the historical record cannot support. Integrated design should record these conflicts rather than silently allowing one criterion to dominate.

Proposition 9.4 (Judgment traceability). *When research judgments materially shape problem selection, exclusion, resource allocation, or inferential ambition, the project should preserve the principal criteria, evidence, uncertainties, and conflicts that supported those judgments.*

Judgment traceability supports later re-evaluation. A project can then revise its priorities without rewriting the earlier decision as irrational or inevitable. The earlier judgment remains intelligible relative to its information and conditions.

9.1.4 Problem Formation

Problem formation converts a field of encounters and judgments into a bounded object of sustained inquiry. The research problem identifies a structured insufficiency in present understanding: a relation that remains unclear, a history that is poorly reconstructed, a mechanism that is disputed, a category whose operation is unstable, a generative process whose conditions are unknown, or a practical contradiction that existing representations do not adequately organize.

A research problem should specify more than a topic. “Trust,” “inequality,” “AI,” “institutions,” or “value” names a domain rather than a problem. Problem formation identifies the difference between what the project needs to understand and what current evidence, concepts, or models can support. That difference can be descriptive, relational, historical, interpretive, causal, generative, normative, or mixed.

Problem formation also establishes provisional boundaries. The relevant actors, institutions, times, scales, relations, and manifestations cannot all remain open indefinitely. Boundary choices should therefore be made explicit enough to permit later sensitivity analysis. A problem framed at organizational scale may conceal field-level dependencies. A national boundary may cut through transnational relations. A contemporary frame may omit the historical conditions that generated the present configuration. A problem definition is therefore provisional even when it is operationally necessary.

The problem should also preserve competing formulations when they imply materially different research designs. An apparent coordination failure can be formulated as an information problem, a relational-trust problem, an institutional-capacity problem, a power problem, or a historically generated option-space problem. Selecting one formulation can redirect data, methods, and inference. Where alternatives remain plausible, the architecture should record them rather than presenting one formulation as naturally given.

Definition 9.5 (Research problem architecture). *A research problem architecture*

specifies the relevant insufficiency in present understanding, the provisional object and boundary of inquiry, the historical and relational context in which the insufficiency arises, and the principal alternative problem formulations that could materially change the design.

Definition 9.5 makes problem formation a design operation. The problem can later be narrowed, expanded, or transformed while retaining a record of why its earlier version was plausible.

9.1.5 Question Formation

Question formation translates the research problem into explicit demands for evidence and inference. A well-formed question identifies what difference the inquiry seeks to resolve and thereby constrains object construction, representation, case selection, data architecture, and method. Chapter 9 develops question types in greater detail in Section 240; the present subsection establishes their place within the project architecture.

A single problem can support several questions. A project concerned with an institutional change may ask what changed, which relations reorganized, how actors interpreted the change, how the configuration emerged historically, whether a specified intervention contributed to it, what capacities or constraints were generated, and how its consequences should be normatively evaluated. These questions should be related without being conflated. Evidence adequate for one can remain inadequate for another.

Question formation should therefore specify the intended epistemic operation. Descriptive questions ask for characterization. Relational questions ask about connections and configurations. Historical questions ask about formation and transformation through time. Interpretive questions ask about meaning. Causal questions ask about difference-making under specified alternatives. Generative questions ask how sources, relations, mechanisms, conditions, and trajectories contribute to later states or possibility structures. Normative questions ask about value, justification, fairness, responsibility, or desirability. Mixed questions require an architecture that distinguishes these components before integrating them.

Questions also have an appropriate level of ambition. A project can ask whether a relation exists without identifying its complete historical formation. It can identify a mechanism in one setting without estimating population prevalence. It can estimate an effect without reconstructing the full option-space transformation that followed. Integrated design should align question strength with available access while leaving room for later expansion when evidence warrants it.

Proposition 9.6 (Question–architecture coupling). *A material change in the research question should trigger review of the objects, boundaries, representations, evidence, methods, inferential bridges, and claim types whose adequacy depended on the earlier question.*

Question revision is therefore consequential rather than merely editorial. The project should record when and why a question changed and identify which downstream components require corresponding revision.

9.1.6 Ontological Position

Every research design operates with some position concerning what kinds of objects, relations, states, events, properties, processes, or structures it will treat as sufficiently stable for inquiry. Generative Relational research preserves ontological suspension, yet suspension does not eliminate the need for operational commitments. The design should state what must be provisionally assumed for the research to proceed and how those assumptions affect representation and evidence.

Ontological position can be layered. At one level, the project may treat persons, organizations, documents, transactions, legal categories, or events as identifiable research objects. At another, it may model relations, capacities, constraints, fields, trajectories, or processes that are reconstructed from manifestations. At a more formal level, it may represent these objects through nodes, edges, states, cells, fields, variables, or morphisms. These layers should remain distinguishable so that formal objects do not silently become ontological declarations.

Operational ontological commitment should be proportional to the question. A study of administrative classification may need to treat institutional categories as operative social facts without claiming that the categories capture ultimate social ontology. A trajectory analysis can represent states and transitions without assuming that the state space is metaphysically fundamental. A partially ordered generative trajectory complex can organize events, couplings, and higher-order composition without claiming that history literally consists of a two-complex. The design should therefore identify the level at which a representation is intended to hold.

Alternative ontological descriptions can sometimes coexist. A relation may be represented as a tie in one analysis, as a field-mediated dependence in another, and as a morphism in a categorical representation. The design should state whether these are competing ontologies, complementary analytical projections, or translations among levels. This distinction affects how evidence can adjudicate among them.

Definition 9.7 (Operational ontological position). An *operational ontological position* is the minimal, explicit set of commitments about research objects and their relevant relations or processes required to construct evidence and perform the intended analysis, together with the scope and revisability of those commitments.

Definition 9.7 makes ontological restraint actionable. The project commits enough to investigate while preserving the possibility that another representation or later theory reorganizes the object.

9.1.7 Epistemic Claim

The epistemic claim states what kind of knowledge the project intends to warrant. It should be specified early enough to discipline evidence and method selection, while remaining revisable when inquiry reveals that the intended claim is too strong, too weak, or incorrectly framed. A design can produce extensive analysis while remaining epistemically unclear if it never states what its findings are meant to establish.

Claim type and claim strength should be separated. A project may make a descriptive claim with high confidence, a mechanism claim with moderate support, a structural-transformation claim limited to one historical setting, and a normative in-

terpretation that remains explicitly contestable. These claims should not inherit a single confidence level merely because they appear in the same study.

Epistemic claims also require scope. Population, period, field, scale, relation type, conditions, and representational assumptions can delimit validity. Strong local evidence does not automatically warrant broad generalization. A formally proven result can be exact within the model while its empirical correspondence remains uncertain. A robust historical reconstruction can support a strong claim about one process while leaving counterfactual magnitude open. The project architecture should preserve these distinctions at the claim level.

Claims concerning generation require particular discipline. A project should state whether it is claiming association, contribution, enablement, mediation, co-generation, strong attribution, structural transformation, or transformation of a generative rule. Chapter 8 established that these roles have different evidential requirements. Chapter 9 uses that distinction to determine what the integrated design must supply.

Proposition 9.8 (Claim-proportion principle). *The intended epistemic claim should remain proportionate to the evidence architecture and inferential bridges that the project can make inspectable, with claim revision available when that proportionality changes during inquiry.*

The proposition makes claim restraint a design property rather than an editing decision made at the end of writing.

9.1.8 Methodological Strategy

Methodological strategy specifies how the project will obtain epistemic access to the components of its question. It includes method selection, sequencing, division of labor among methods, integration points, and criteria for revision. The strategy should follow the object and claim rather than disciplinary habit.

A project may have one core method and several supporting methods. Historical reconstruction can provide the primary architecture while quantitative analysis examines prevalence. Longitudinal data can identify trajectories while qualitative process evidence reconstructs mechanisms. Formal models can specify competing generative structures while archival evidence discriminates among them. Simulation can test whether a mechanism family is capable of producing an observed pattern, while empirical work assesses whether the encoded relations occurred. Intervention can provide contrastive evidence while process tracing examines what the intervention changed.

Method sequence can itself matter. Early qualitative inquiry can improve variable construction. Historical reconstruction can prevent a contemporary dataset from treating changing categories as stable. Formalization can reveal which observations would distinguish competing mechanisms. Simulation can expose sensitivity to initial conditions and motivate new data collection. Later fieldwork can show that a model parameter conflates two institutionally different processes. The strategy should therefore identify both the intended sequence and the conditions under which that sequence can change.

Methodological economy also matters. A project does not become stronger merely by accumulating methods. Each method imposes costs in data, interpretation, time, technical maintenance, and integration. Redundant methods can be valuable when they provide partially independent checks; they can also create apparent sophistication without increasing warrant. The strategy should justify what each method contributes and identify where a simpler method would preserve the relevant differences.

Definition 9.9 (Methodological strategy). A *methodological strategy* is the project-level specification of which methods provide access to which components of the research question, how those methods are sequenced or combined, what inferential role each performs, and what evidence would motivate their revision, supplementation, or removal.

This definition prepares the more detailed method-portfolio and sequencing sections later in the chapter.

9.1.9 Evidence Architecture

Evidence architecture specifies how observations, records, measurements, interpretations, comparisons, interventions, simulations, and derived representations bear on the components of the intended claims. Its role is to prevent heterogeneous materials from being treated as interchangeable merely because they coexist within one project.

The architecture should map evidence to function. One source may establish that an event occurred. Another may support the identity of a relation. A longitudinal series may estimate temporal change. An interview may clarify interpretation or mechanism. An archival record may establish sequence and institutional context. A natural experiment may provide counterfactual leverage. A simulation may test the implications of a candidate mechanism. A formal proof may establish a property of a representation. These evidential functions can complement one another while remaining distinct.

Provenance should be preserved at the same level. Evidence collected directly, derived computationally, inferred historically, generated through intervention, simulated under assumptions, or produced through AI-assisted transformation should remain distinguishable. The project should also record relevant transformations: cleaning, coding, aggregation, imputation, translation, classification, embedding, model fitting, or summarization. This permits later investigators to reconstruct where an evidential claim entered the architecture and which operations affected it.

Evidence architecture also includes absence and conflict. Missing records can constrain inference. Divergent sources can indicate category mismatch, scale difference, selective observation, or genuine historical disagreement. A well-designed architecture preserves such differences long enough to investigate them rather than resolving them automatically through majority, convenience, or format compatibility.

The partially ordered generative trajectory complex developed in Chapter 8 can serve as one optional evidence-integration substrate when event order, coupling, higher-order composition, competing histories, and provenance are central.

Observed vertices, inferred edges, uncertain faces, simulated extensions, and counterfactual branches can carry different evidential annotations. Simpler projects can use correspondingly simpler evidence maps. The architectural principle is the same: evidence remains attached to the claim component it supports.

Proposition 9.10 (Evidence-role explicitness). *Evidence integration becomes more inspectable when each major evidential source is associated with the object, relation, sequence, mechanism, comparison, structural feature, scale transition, or robustness claim for which it provides support, together with its provenance and uncertainty.*

Evidence-role explicitness also makes gaps visible. The project can then distinguish a missing data source from a missing inferential bridge.

9.1.10 Revision Plan

A revision plan completes the initial project architecture by specifying how the design can change. Revision is expected because research encounters evidence, relations, categories, mechanisms, and constraints that were unavailable at the beginning. The relevant methodological question is therefore how revision will be triggered, documented, propagated, and evaluated.

Revision triggers can arise at several levels. New evidence can undermine object identity. A category can prove historically unstable. A method can fail to access the intended relation. A model can fit observations while relying on implausible mechanisms. A robustness test can reveal boundary sensitivity. An ethical problem can make a planned intervention unacceptable. A new encounter can transform salience and redirect the question. The revision plan should identify which kinds of evidence require local adjustment and which require reconsideration of the broader architecture.

Revision propagation is especially important. Changing the research question can alter case selection, data requirements, and claim type. Revising an ontological assumption can invalidate a representation. Changing a field boundary can alter network measures and historical interpretation. Reclassifying a variable can affect longitudinal comparability. Replacing a mechanism can change the relevant counterfactual. Integrated design should therefore record dependencies sufficiently to identify which downstream components need review when an upstream component changes.

The project should also preserve superseded states. Earlier questions, coding schemes, models, interpretations, and failed analyses can remain useful for understanding why the project changed and for enabling future re-epistemization. Version preservation is especially valuable when revision involves category change or model replacement, because later investigators may judge the older representation differently under new evidence.

Definition 9.11 (Research revision plan). *A research revision plan specifies the conditions that can trigger reconsideration of project components, the dependencies through which revision should propagate, the provenance that should be preserved across versions, and the criteria for deciding whether revision narrows, redirects, extends, or replaces the existing design.*

A revision plan should remain proportionate. Exploratory projects can use

lightweight logs and decision points; large collaborative or intervention-based projects may require formal versioning, governance, approval procedures, and audit trails. The principle is that revision should be visible enough to distinguish learning from unnoticed drift.

Proposition 9.12 (Revisable project coherence). *An integrated research project remains coherent through substantial revision when changes to encounter interpretation, problem, question, ontological position, claim, method, or evidence are propagated to the dependent components of the architecture and earlier states remain sufficiently documented for the rationale of change to be reconstructed.*

Proposition 9.12 summarizes the architecture developed in this section. Encounter provides the initial contact with a possible research object. Salience allocates attention. Judgment attributes provisional significance. Problem formation identifies the insufficiency to be investigated. Question formation specifies the epistemic demand. Ontological position makes the operative object explicit. The epistemic claim defines the intended level of warrant. Methodological strategy organizes access. Evidence architecture links materials to inferential roles. Revision planning keeps the project capable of learning from its own inquiry.

The architecture remains recursive. A later method can produce a new encounter; new evidence can transform salience; revised judgment can reformulate the problem; problem revision can alter the question; the question can require a different ontological representation; and the new representation can expose previously unavailable evidence. Section 240 develops the next design layer by differentiating the principal structures that research questions can take and by showing how mixed and changing questions reorganize the rest of the project.

9.2 Research Question Architecture

This section develops research-question architecture as the design layer through which a broad research problem becomes a set of inferentially differentiated questions. Its role within Chapter 9 is to refine the question-formation component of Section 9.1 and to make explicit how different question types impose different requirements on objects, evidence, representation, method, temporal scope, and claim strength. The objective is to distinguish descriptive, relational, historical, interpretive, causal, generative, and normative questions; to show how those forms can be combined without losing their inferential identities; and to specify how research questions can be transformed when the inquiry changes. The discussion is conceptual and design-oriented. Each question type is treated through the kind of difference it seeks to establish, the evidential work required to support it, and the downstream consequences that its formulation creates for the rest of the research architecture.

Research questions do more than communicate topics. A question specifies what kind of difference the project is trying to make knowable. A descriptive question may seek the distribution or composition of an observed phenomenon. A relational question seeks the structure or character of connections among objects. A historical question reconstructs change through time. An interpretive question concerns meaning, classification, perspective, or symbolic mediation. A causal question concerns

difference-making under specified alternatives. A generative question concerns the processes through which capacities, constraints, relations, structures, or possibilities emerge and transform. A normative question concerns evaluative standards, justification, obligation, justice, or the desirability of arrangements. These forms overlap in substantive projects, yet their inferential burdens remain distinguishable.

The architecture of the research question should therefore be explicit enough to prevent one form of inquiry from silently carrying the evidential burden of another. Description can motivate explanation while leaving causal attribution open. Historical sequence can reveal process structure while leaving counterfactual dependence uncertain. Interpretation can identify meaning-mediated mechanisms while leaving population-level prevalence unresolved. A causal estimate can establish a contrast while leaving the mechanism or historical formation of the contrast unspecified. Generative reconstruction can identify how later possibilities are produced while leaving their normative desirability open. Normative evaluation can assess institutions or outcomes while relying on empirical premises that require independent support.

Definition 9.13 (Research question architecture). *A research question architecture is the documented organization of one or more research questions according to their inferential type, target object, temporal and spatial scope, relevant alternatives, evidential requirements, and relations to other questions in the project.*

Definition 9.13 treats question formulation as an architectural decision rather than a wording exercise. The same substantive topic can support different projects depending on whether the central task is to describe a distribution, reconstruct a relation, explain a transformation, estimate a causal contrast, identify a generative mechanism, or evaluate a normative arrangement. Integrated design therefore records both the substantive object and the epistemic operation requested of the inquiry.

A question architecture can also contain hierarchy. Some questions are foundational because later questions depend on their answers. A causal question can require prior descriptive and relational specification. A generative question can require historical reconstruction, interpretive work, or causal contrasts. A normative question can depend on descriptive facts, causal consequences, institutional histories, and explicit evaluative principles. The architecture should make such dependencies visible so that evidential failure in an upstream question can propagate appropriately to downstream claims.

Proposition 9.14 (Question–design coupling). *A research design becomes more internally coherent when the inferential type and scope of each research question are specified before evidence and methods are treated as adequate for answering it.*

Proposition 9.14 does not require questions to remain fixed throughout the project. It requires the current question to be sufficiently explicit that methods and evidence can be evaluated relative to it. When the question changes, the architecture should record the change and propagate the revision to the affected design components.

9.2.1 Descriptive Questions

Descriptive questions establish the composition, distribution, frequency, variation, organization, or observed characteristics of a research object under specified con-

ditions. Their role in an integrated project is foundational because later relational, causal, generative, and normative claims often depend on accurate specification of what is present, how it is distributed, and how it is recorded. Description can be qualitative, quantitative, historical, spatial, relational, or mixed. Its epistemic function is to characterize rather than to assign difference-making responsibility.

A descriptive question should identify the object being described, the population or field to which the description applies, the observation system through which the object becomes visible, and the relevant dimensions of variation. A statement about the frequency of an institutional practice requires a different observation architecture from a statement about the meanings attached to that practice. A description of a network requires specification of nodes, edge types, temporal resolution, and boundary conditions. A description of capability distribution requires a defensible operational account of capability rather than a proxy whose relation to capability remains unspecified.

Descriptive questions can therefore carry substantial conceptual burden. Categories determine which differences become countable or narratable. Measurement intervals determine which temporal changes become visible. Field boundaries determine which entities enter the denominator. Archival survival determines which historical events remain observable. The descriptive layer should preserve these conditions because later explanatory work often inherits them.

A useful descriptive architecture distinguishes at least four elements: the object of description, the descriptive dimensions, the observation or recording system, and the scope of generalization. The project can then state whether a finding concerns the observed sample, a defined population, a historical archive, a constructed dataset, a field site, or another bounded evidential domain. This prevents a descriptive regularity from silently acquiring a wider scope than the design supports.

Descriptive questions also contribute to anomaly detection. A distributional discontinuity, unexpected concentration, missing category, recurring pattern, or atypical configuration can redirect the project toward new relational or generative questions. The descriptive layer can therefore function as an encounter surface within an integrated design. Its contribution becomes especially important when the project preserves enough provenance to distinguish an empirical anomaly from a change in classification, instrumentation, or data coverage.

Definition 9.15 (Descriptive question). A *descriptive question* asks how a specified object, configuration, distribution, or observed difference is characterized within a defined evidential domain, without by itself assigning causal, generative, or normative status to that characterization.

Definition 9.15 allows description to be analytically rich while preserving its inferential boundary. Description can reveal patterns that later become evidence for stronger claims, but those claims require additional bridges.

9.2.2 Relational Questions

Relational questions ask how objects, actors, institutions, categories, states, properties, or processes are connected, differentiated, coordinated, dependent, coupled, or

positioned relative to one another. Their role is to convert isolated descriptions into a representation of relational structure. Chapter 7 developed the methodological requirements for relational identification in detail; within Chapter 9, the design task is to formulate relational questions with enough specificity that the relation under investigation is distinguishable from mere co-occurrence or analyst-imposed adjacency.

A relational question should specify the relata, the type of relation, its directionality where relevant, temporal persistence, scale, and evidential signature. Trust, authority, exchange, dependency, kinship, legal obligation, communication, similarity, ownership, co-membership, and causal coupling are different relation types. A project that asks whether two actors are connected without specifying the relevant relation risks treating heterogeneous links as interchangeable.

Relational questions can concern dyadic, higher-order, field-level, or multiscale structures. A dyadic question may ask how two organizations coordinate. A higher-order question may concern a coalition whose properties cannot be reduced to the sum of pairwise ties. A field-level question may concern positions defined by a wider configuration. A multiscale question may ask how household, organizational, and institutional relations interact. The question architecture should therefore match the representational level to the relational phenomenon rather than defaulting to pairwise or individual-level analysis.

Relational questions also have boundary consequences. A relation can appear central or peripheral depending on which surrounding ties are included. Network membership, institutional jurisdiction, field definition, and temporal window can therefore alter the observed relational structure. The project should record these boundary choices and, where materially relevant, plan sensitivity analysis across plausible alternatives.

Relational inquiry can support stronger generative questions when it identifies pathways, dependencies, or structural positions through which later differences may emerge. The relational question itself remains narrower. It establishes or characterizes a relation and can assess its persistence, configuration, or consequence without automatically establishing the mechanism through which the relation generates later outcomes.

Proposition 9.16 (Relational specification). *The evidential value of a relational question increases when the relata, relation type, boundary, temporal scope, scale, and expected evidence are specified before relational data are interpreted.*

Proposition 9.16 makes relational design inspectable. It also facilitates later translation into graph, geometric, field, algebraic, categorical, or spacetime representations because the empirical relation precedes the formal encoding.

9.2.3 Historical Questions

Historical questions reconstruct formation, sequence, change, persistence, rupture, path dependence, and transformation across time. Their role in an integrated design is to establish how the present or a later configuration became historically available. Historical inquiry therefore concerns more than dating events. It can recon-

struct changing categories, institutions, relations, capacities, constraints, evidential systems, and option spaces, together with the contingent sequences through which those changes developed.

A historical question should specify the temporal object and the temporal resolution relevant to the process. The history of a legal category can require attention to legislative episodes, administrative practice, litigation, and changing interpretation. The history of an infrastructure can require long periods of accumulation interrupted by short periods of rapid transformation. The history of a relation can require event-level evidence at one stage and institutional records at another. A uniform temporal grid can therefore conceal the heterogeneous tempos through which the historical object changes.

Historical questions also require periodization. Start and end points shape which antecedents, transitions, and consequences become visible. A reform studied from the date of enactment can appear abrupt; a longer horizon may reveal decades of institutional preparation. A contemporary category projected backward can appear stable; archival reconstruction may reveal semantic discontinuity. Integrated design should therefore treat periodization as a substantive choice whose alternatives may need explicit comparison.

A further design issue concerns historical evidence. Archives, administrative records, newspapers, correspondence, oral histories, material traces, datasets, and retrospective testimony preserve different aspects of a process and have different survival conditions. Historical questions should be coupled to an evidence architecture that records both presence and silence. Missing records can reflect non-occurrence, destruction, exclusion from official recording, inaccessible archives, or changes in classificatory practice. Historical reconstruction should preserve these alternatives where they affect inference.

Historical questions can be descriptive, interpretive, causal, or generative in orientation. A project may ask how an institution changed, how contemporaries interpreted the change, which events contributed to it, or how the transformation altered later possibility. The historical dimension therefore does not determine the full inferential type. It specifies the temporal organization within which other question types operate.

Definition 9.17 (Historical question). A *historical question* asks how a specified object, relation, category, institution, process, or possibility structure formed, persisted, changed, or dissolved across a defined temporal horizon and evidential record.

Definition 9.17 keeps historical reconstruction distinct from a mere chronology. The relevant object is the transformation itself and the historical conditions through which it becomes intelligible.

9.2.4 Interpretive Questions

Interpretive questions concern meaning, classification, perspective, symbolic mediation, practical understanding, and the categories through which actors and institutions render situations intelligible. Their role in integrated design is to make explicit the interpretive layer through which actions, records, rules, and observed regulari-

ties acquire significance. An interpretive question can ask how actors understand an institution, how a legal category is applied, how a narrative organizes expectation, or how a symbolic distinction changes the practical meaning of an economic relation.

Interpretive questions require specification of whose interpretation is being reconstructed and through which materials. Researcher interpretation, participant interpretation, institutional classification, legal interpretation, and historically inherited discourse should remain distinguishable. A project can legitimately move among these levels, yet the movement should be documented because each level carries different evidential sources and inferential commitments.

The relevant evidence can include interviews, texts, records of practice, legal reasoning, discourse, observed interaction, classification systems, visual materials, or other symbolic forms. Interpretation gains methodological strength when the project identifies how the meaning claim is supported, where competing interpretations exist, and how the interpretation relates to action or institutional consequence. Repetition of a term does not by itself establish that the term has the same meaning across actors or periods.

Interpretive questions can also expose category instability. A variable that appears stable in a quantitative dataset may refer to changing institutional meanings. A legal category may remain textually constant while administrative interpretation changes. A policy concept may travel across organizations and acquire different practical content. Integrated design should therefore permit interpretive work to revise measurement, historical periodization, case comparison, and formal representation.

Interpretive inquiry has a distinctive relation to generative research. Meanings can participate in generative mechanisms when classifications, expectations, narratives, identities, or symbolic distinctions alter action, coordination, legitimacy, recognition, or institutional access. The interpretive question establishes the meaning structure; a stronger generative question additionally asks how that structure contributes to later capacities, constraints, relations, or possibilities.

Proposition 9.18 (Interpretive dependency). *A research design should make interpretive dependencies explicit whenever measurement, categorization, comparison, or mechanism claims rely on the meaning assigned to symbols, practices, institutional categories, or actors' understandings.*

Proposition 9.18 gives interpretive inquiry a project-wide role. Interpretation can be a primary method, a supporting method, or a validation layer for categories used elsewhere in the design.

9.2.5 Causal Questions

Causal questions concern difference-making under specified alternatives. Their role within integrated design is to identify whether a defined exposure, intervention, condition, relation, or event contributes to variation in a defined outcome under an explicit comparison structure. The design burden lies in specifying the contrast, target population or domain, temporal horizon, assumptions required for identification, and forms of interference or heterogeneity that may affect the estimate.

A causal question should identify the treatment or causal contrast with greater

precision than ordinary topic language often provides. A policy name can contain several interventions. An institutional reform can be enacted differently across sites. Exposure can vary in intensity, timing, duration, or composition. A relation can act as both treatment and pathway. Integrated design should therefore define the causal contrast at the level at which counterfactual comparison is meaningful.

The outcome requires comparable care. Immediate measured outcomes can differ from longer-term capacities, constraints, institutional changes, or option spaces. An intervention can improve one outcome while generating downstream effects elsewhere. A causal question can legitimately focus on a narrow outcome, yet the design should avoid treating that outcome as a complete representation of generative consequence when broader effects matter to the research problem.

Causal questions also depend on assumptions concerning assignment, confounding, interference, measurement, missingness, and transport. Experimental, quasi-experimental, observational, comparative, and historical strategies provide different forms of leverage. Their adequacy should be evaluated relative to the question and target claim rather than through a hierarchy of method labels. In relational settings, interference can be especially consequential because one actor's exposure can alter another actor's outcome through networks, institutions, or shared environments.

The relation between causal and generative questions deserves explicit design treatment. A credible causal contrast can establish that a specified intervention made a difference to a specified outcome. A generative account can then ask how the difference arose, which pathways mediated it, which capacities or constraints changed, how effects propagated, and whether the intervention transformed later possibility. The two question types can therefore be coupled without being treated as interchangeable.

Definition 9.19 (Causal question). A *causal question* asks what difference a specified exposure, intervention, condition, relation, or event makes to a defined outcome relative to an explicit or reconstructable alternative under stated assumptions and scope conditions.

Definition 9.19 places the comparison structure inside the question architecture. This helps prevent causal language from expanding beyond the contrast the design can support.

9.2.6 Generative Questions

Generative questions ask how later states, relations, capacities, constraints, structures, option spaces, trajectories, or generative rules emerge, transform, persist, propagate, or become accessible through specified processes and conditions. Their role in Chapter 9 is central because they translate the methodological resources of Chapter 8 into project-level question design. A generative question usually requires more internal structure than a single outcome contrast because it concerns the organization of production across time.

A generative question should specify at least the generated object, candidate generative source or configuration, conditions, constraints, scale, temporal horizon, relevant alternatives, and intended strength of attribution. These elements need not all

appear in one sentence. They should be recoverable from the question architecture. The project can then select methods that correspond to the required components: process tracing for intermediate states, longitudinal analysis for temporal development, historical reconstruction for formation, formal modeling for transition structure, simulation for alternative trajectories, or intervention for action-generated evidence.

Generative questions are especially useful when the research interest concerns potential rather than only realized outcome. A new capability can exist before it is exercised. An institution can alter future option spaces before aggregate indicators change. A relation can create a dependency whose consequences remain latent until another condition appears. A generative question can therefore target changes in what becomes possible, accessible, stable, constrained, or reproducible.

The partially ordered trajectory-complex representation developed in Chapter 8 provides one optional formal interface for such questions. A project can ask which event order, couplings, higher-order processes, or rule transformations are required to reconstruct an observed history. Alternative histories can remain explicit where evidence leaves several admissible paths. The question architecture should nevertheless remain prior to the representation: the trajectory complex is useful when it preserves distinctions the question requires, and unnecessary when a simpler representation is adequate.

Generative questions also need attributional restraint. A project can investigate contribution, enablement, mediation, co-generation, structural transformation, or rule change without assuming exclusive causation. The question should therefore use language proportionate to the intended inferential burden. Asking how a relation contributes to later capability differs from asking whether it is sufficient for that capability, and both differ from asking whether the relation is necessary.

Proposition 9.20 (Generative question specification). *A generative research question becomes design-ready when the generated object, candidate source configuration, conditions, scale, temporal horizon, relevant alternatives, and intended attributional strength are sufficiently specified to guide evidence and method selection.*

Proposition 9.20 converts generative ambition into design requirements. It also provides a diagnostic tool: when one component remains vague, the project can identify precisely what additional conceptual or empirical work is needed.

9.2.7 Normative Questions

Normative questions concern evaluation, justification, obligation, legitimacy, justice, responsibility, or the desirability of arrangements and actions. Their role in integrated research design is to make evaluative commitments explicit and to identify which empirical premises, conceptual distinctions, and normative principles support the conclusion. Normative inquiry can be central to GRE because economic processes affect capacities, constraints, value conversion, power, return, recognition, and future possibility, yet those effects do not evaluate themselves.

A normative question should identify the evaluative object and the standard or family of standards under consideration. A project can evaluate a distribution, institution, relation, policy, generative process, decision rule, or option-space transforma-

tion. The standard can concern fairness, capability, liberty, reciprocity, recognition, non-domination, sustainability, responsibility, or another explicitly defended criterion. Integrated design should preserve disagreements among standards when they materially change the conclusion.

Normative questions often depend on empirical claims. An evaluation of an institution can rely on evidence concerning who gains capacity, who bears constraint, how benefits and burdens persist, whether alternatives are feasible, and how effects are distributed over time. The empirical architecture should remain distinguishable from the normative inference so that disagreement about facts can be separated from disagreement about evaluative premises.

Normative inquiry can also reshape empirical design. A concern with distribution can require disaggregated data that an average outcome conceals. A concern with future generations can require a longer temporal horizon. A concern with domination can require relational evidence rather than only resource measures. A concern with recognition can require interpretive evidence concerning status and classification. The normative question can therefore affect what the project needs to observe without converting empirical evidence into a self-sufficient normative conclusion.

A further distinction concerns actor-relative and system-level evaluation. An arrangement can expand aggregate capacity while concentrating dependency. A standardized institution can increase coordination while narrowing local option spaces. An intervention can improve short-run outcomes while shifting long-run risk. Normative question architecture should therefore specify the relevant actors, scales, time horizons, and distributions whenever these choices affect evaluation.

Definition 9.21 (Normative question architecture). *A normative question architecture specifies the object of evaluation, the relevant actors and scales, the evaluative principles or criteria, the empirical premises on which the evaluation depends, and the principal alternative interpretations or standards that could alter the conclusion.*

Definition 9.21 makes normative reasoning inspectable while preserving legitimate plurality. The aim is traceable evaluation rather than the appearance of value neutrality.

9.2.8 Mixed Question Structures

Many substantial research projects contain several question types. Mixed question structures coordinate descriptive, relational, historical, interpretive, causal, generative, and normative components within one project while preserving the inferential identity of each component. Their role is to permit substantive breadth without allowing one kind of evidence to stand in silently for another.

A mixed architecture can be hierarchical. Descriptive work can establish a pattern; relational inquiry can identify relevant connections; historical reconstruction can establish formation; interpretive analysis can clarify meaning; causal analysis can estimate a specified contrast; generative inquiry can reconstruct pathways and changes in possibility; normative inquiry can evaluate the resulting configuration. The sequence can differ across projects, and some components may be unnecessary. What matters is that dependencies among them are explicit.

Mixed structures can also be parallel. A project may carry two competing generative explanations, each requiring a different evidence stream. It may compare a causal estimate with an interpretive reconstruction without requiring one to validate the other. It may combine historical and computational work to investigate different parts of a process. Parallel architecture is useful when methodological plurality reflects genuinely different access routes rather than a sequence of verification steps.

The risk in mixed designs is inferential blending. A rich qualitative narrative can make a causal estimate feel more mechanism-complete than the evidence warrants. A statistically precise estimate can make an interpretive classification appear more stable than it is. A sophisticated simulation can create confidence in a historical mechanism whose empirical traces remain weak. Integrated design should therefore assign evidence to the question component it actually supports and document the inferential bridge when evidence is carried across components.

Definition 9.22 (Mixed question structure). *A mixed question structure is an organized set of research questions of different inferential types whose dependencies, evidential roles, and claim boundaries are recorded separately while contributing to a shared research problem.*

A mixed structure can be represented as a dependency graph in project documentation even when no mathematical graph is used in the manuscript. Nodes can represent question components and directed dependencies can record which answers, assumptions, or evidence architectures constrain later questions. This makes it easier to revise one component without silently invalidating another.

Proposition 9.23 (Inferential separation within mixed design). *Mixed research designs become more revisable when each question component retains its own evidential requirements and attributional boundaries, while the project records the bridges through which components inform one another.*

Proposition 9.23 supports methodological plurality without producing methodological accumulation for its own sake. A mixed design should remain as simple as the research problem permits while preserving the distinctions required by the claims.

9.2.9 Transformation of the Research Question

Research questions can change substantially during inquiry. Transformation of the research question concerns the documented revision of the inferential target, object, scope, temporal horizon, comparison structure, or normative orientation in response to new evidence, conceptual clarification, field conditions, ethical constraints, failed assumptions, or newly encountered phenomena. Its role in integrated design is to make such transformation cumulative and inspectable rather than treating question change as a hidden deviation from an initial plan.

Question transformation can take several forms. A descriptive question can become relational when an observed distribution is explained by position in a network. A relational question can become historical when the relation proves unstable across periods. An interpretive question can acquire a generative component when meaning is found to mediate later action. A causal question can narrow after treatment heterogeneity is discovered. A generative question can shift scale when the mecha-

nism operates at an institutional rather than individual level. A normative question can change when the affected population or relevant time horizon expands.

Transformation can also reduce ambition. A project may begin with a strong causal or generative question and discover that the available evidence supports only description, relational reconstruction, or historical interpretation. Such narrowing can represent methodological improvement because the revised question is better aligned with the evidence. Integrated design should therefore record reductions in claim scope as substantive research decisions rather than as failures to answer the original question.

The reverse movement is also possible. New evidence can justify a stronger question. Dense process evidence can motivate a mechanism analysis. Longitudinal data can make delayed effects observable. A newly available archive can support historical reconstruction. A natural experiment can create causal leverage. Stronger questions should be accompanied by corresponding expansion of evidence and method rather than by rhetorical escalation alone.

Question transformation has downstream effects. Case selection, field boundaries, data requirements, representation, method portfolio, uncertainty architecture, and documentation can all require revision. The project should therefore maintain versioned questions and record the principal design consequences of each revision. This preserves the history of inquiry and permits later researchers to understand why earlier analyses were abandoned, narrowed, or reframed.

Definition 9.24 (Question transformation record). *A question transformation record documents the earlier question, the revised question, the encounter or evidential development motivating the change, the altered inferential commitments, and the project components requiring revision as a consequence.*

Question transformation completes the architecture developed in this section. Descriptive, relational, historical, interpretive, causal, generative, and normative questions can each organize a legitimate research project. Mixed designs can combine them when their inferential roles remain visible. Versioned transformation allows the architecture to change without losing the history of how the inquiry developed. The next section turns from question architecture to theory-to-design translation: how theoretical concepts become research objects, representations, evidence requirements, methods, inferences, and ultimately claims while preserving the losses and assumptions introduced at each translation step.

9.3 Theory-to-Design Translation

This section develops theory-to-design translation as the design layer through which theoretical commitments become researchable objects, representations, evidence requirements, methodological operations, inferences, and claims. Its role within Chapter 9 is to connect the question architecture of Section 9.2 with the concrete design choices developed in the remaining sections of the chapter. The objective is to make explicit where meaning, scope, and uncertainty are introduced or lost as a project moves from abstract concepts toward empirical and formal operations. The discussion proceeds through eight translation stages: concept to object, object to representa-

tion, representation to evidence, evidence to method, method to inference, inference to claim, translation loss, and revision of theoretical terms. The method is reconstructive and design-oriented. Each stage is treated as a documented relation rather than as an automatic conversion.

Theory enters research design through concepts that organize attention before they become measurable or formally represented. Terms such as capacity, constraint, trust, dependency, institution, field, option space, generativity, relational position, structural transformation, or historical accessibility can guide inquiry while remaining too broad for direct observation. Research design therefore requires a sequence of interpretive and operational decisions. Those decisions do not merely implement a theory that is already complete. They partly determine what version of the theoretical concept becomes empirically accessible.

The translation problem becomes especially important in Generative Relational research because many of its concepts are intentionally relational, multiscale, historically situated, and open to several representations. A relation can be represented as an interview-derived practice, a legal obligation, a network edge, a contractual dependency, a stochastic transition, a field coupling, or a higher-order cell in a generative trajectory complex. These representations can illuminate different aspects of the same theoretical object while preserving different forms of information. Integrated design therefore benefits from recording the translation path rather than treating the chosen representation as identical to the theory.

Definition 9.25 (Theory-to-design translation). *A theory-to-design translation is the documented sequence of interpretive, representational, evidential, methodological, and inferential decisions through which a theoretical concept or proposition becomes a research object, a representation, an evidence architecture, a method strategy, an inference, and a scoped claim.*

Definition 9.25 places documentation inside the translation process. The same theoretical term can support several legitimate research designs, and each design can preserve or suppress different distinctions. The relevant question is therefore not whether a design perfectly reproduces the theory, but whether the translation is explicit enough that the relation between theory and evidence can be inspected and revised.

Theory-to-design translation also operates in both directions. Theory constrains object construction and representation, while empirical difficulty, unexpected evidence, failed measurement, and model incompatibility can reveal that the theoretical concept requires revision. Translation is therefore part of theory development within research praxis rather than a one-way movement from abstract formulation to technical implementation.

Proposition 9.26 (Traceable translation). *A research design becomes more revisable when each transition from theory to claim records the source concept, the chosen representation, the evidence required, the method applied, the assumptions introduced, and the information that remains outside the chosen translation.*

Proposition 9.26 provides the organizing principle for the section. The design goal is traceability across a chain of commitments, together with enough retained remainder to make later reinterpretation possible.

9.3.1 Concept to Object

Concept-to-object translation concerns the transformation of a theoretical concept into a bounded object of inquiry. Its role is to specify what the project will treat as an instance, manifestation, configuration, or historical realization of a concept without assuming that the concept and the object are identical. A concept can remain broader than any particular research object, and several object constructions can be compatible with the same theoretical vocabulary.

A theoretical concept often contains several dimensions. Capacity can include knowledge, authorization, resources, coordination, infrastructural support, and practical accessibility. Dependency can include asymmetry of alternatives, substitutability, switching cost, institutional exposure, or temporal lock-in. Trust can involve expectation, vulnerability, recognition, repeated interaction, symbolic mediation, and institutional guarantee. Translating such a concept directly into a single observed variable can suppress dimensions that matter to the theory.

The first design task is therefore to identify the concept's constitutive distinctions and decide which of them are relevant to the question. This decision should be recorded as an object specification. The specification can identify the units or configurations being studied, the relation types that matter, the temporal horizon, the scale, the boundary of the field, and the conditions under which the object is considered present, transformed, or absent.

Object construction can be case-specific without becoming arbitrary. A study of institutional capacity may define its object through formal authorization, staffing, procedural competence, infrastructural continuity, and demonstrated coordination. Another project can study epistemic capacity through access to information, interpretive competence, validation practices, and the ability to revise belief. Both may belong to the theoretical family of capacity while requiring different object architectures.

Definition 9.27 (Research-object translation). A *research-object translation* specifies how a theoretical concept is instantiated for a particular inquiry by identifying the entities, relations, states, processes, properties, events, scales, boundaries, and conditions that constitute the object under study.

Definition 9.27 permits object construction to be plural while remaining accountable. The project should be able to explain why the selected object captures the aspect of the theoretical concept relevant to the research question and which aspects remain outside the present design.

Object construction also establishes exclusion criteria. A formal rule can be relevant to institutional capacity while remaining insufficient evidence of enacted capacity. A pairwise relation can be relevant to coalition structure while remaining insufficient to represent a higher-order configuration. A resource measure can be relevant to option space while remaining insufficient to establish practical accessibility. Explicit exclusion criteria help prevent convenient observations from silently redefining the concept.

The relation between theoretical and empirical objects can also change historically. A category that currently has a legal or administrative form may have existed earlier through custom, practice, or another classification. Integrated design should there-

fore permit historically variable object specifications when stable modern categories would distort the earlier field. Historical comparison can then operate through documented translation among object forms rather than forced identity across periods.

Proposition 9.28 (Object-scope discipline). *A theoretical concept supports stronger empirical inquiry when the research object preserves the distinctions required by the question while making explicit which dimensions of the broader concept remain outside the current object specification.*

The object layer is therefore the first substantive commitment in theory-to-design translation. Once the object is specified, the project must decide how that object will be represented.

9.3.2 Object to Representation

Object-to-representation translation concerns the construction of a form in which the research object can be inspected, compared, measured, reconstructed, or modeled. Its role is to connect the substantive object to an analytical medium without treating the representation as the object itself. A representation can be textual, classificatory, numerical, spatial, relational, geometric, dynamical, categorical, computational, or mixed.

Representation requires selection. A historical institution can be represented through a chronology, an event graph, an archive-coded process trace, a network, a state-transition model, or a partially ordered generative trajectory complex. Each representation foregrounds certain differences and suppresses others. A network emphasizes relational topology. A process trace emphasizes sequence and intermediate states. A dynamical model emphasizes state and transition structure. A generative trajectory complex can preserve event order, coupling, higher-order composition, and provenance while remaining less convenient for some statistical operations.

The design should therefore state the analytical role of the representation. A representation may be intended for description, comparison, mechanism reconstruction, estimation, simulation, integration across methods, or communication. A representation that is adequate for one role can remain weak for another. A cross-sectional adjacency matrix may describe observed ties while providing little access to their historical formation. A smooth trajectory can summarize change while concealing uncertain intermediate events. A category-theoretic mapping can clarify translation structure while providing no empirical measurement by itself.

Definition 9.29 (Representation contract). *A representation contract records the object features a representation is intended to preserve, the analytical operations it is intended to support, the assumptions required by its form, and the object features that the representation leaves unresolved or suppresses.*

A representation contract makes abstraction inspectable. For a network representation, the contract can specify node identity, edge type, directionality, multiplicity, higher-order structure, time dependence, and boundary rules. For a geometric representation, it can specify the meaning of coordinates, distance, neighborhood, and scale. For a simulation, it can specify which processes are encoded as rules, param-

eters, stochastic transitions, or exogenous inputs. For the generative trajectory complex, it can specify the semantics of vertices, edges, faces, partial order, typing, and provenance annotations.

Representation also introduces equivalence judgments. Two empirical configurations can be represented as equivalent under a chosen classification even when they differ in other respects. Two institutional histories can occupy the same aggregate state while differing in path. Two relations can receive the same edge label while carrying different meanings or powers. Such equivalence can be methodologically useful, but the criterion should remain visible because later inference inherits it.

Multiple representations can sometimes be maintained in parallel. A qualitative process map and a network model can represent different aspects of the same field. A historical event complex can coexist with a statistical panel. The project should record translation relations among them rather than forcing one representation to absorb the others. This is especially important when representations use different units, temporal resolutions, or ontological commitments.

Proposition 9.30 (Representation plurality). *Parallel representations can strengthen an integrated design when each representation has a defined analytical role and translations among them preserve the differences required by the research question.*

The representation layer prepares the evidential problem. Once the object has been rendered in an analytical form, the project must specify what observations could support, challenge, or revise that representation.

9.3.3 Representation to Evidence

Representation-to-evidence translation concerns the relation between an analytical representation and the empirical or historical traces used to populate, constrain, validate, or revise it. Its role is to prevent a representation from becoming self-confirming. Evidence should enter through specified access routes whose relation to the represented object is documented.

A representation creates evidential requirements. A network requires evidence of node identity, relation type, and boundary. A process trace requires temporally ordered traces, intermediate states, and mechanism signatures. A geometric model requires evidence supporting the chosen coordinates, distances, or neighborhoods. A stochastic model requires evidence concerning transitions, distributions, or variability. A generative trajectory complex requires evidence for event vertices, coupling edges, higher-order cells, partial order, typing, and provenance status.

The evidential requirement can be direct or inferential. Some events may be documented through contemporaneous records. Some relations may be inferred from repeated coordinated action. Some institutional constraints may become visible through procedural records, testimony, and observed exclusions. Some latent capacities may require indirect evidence from enabling conditions and demonstrated readiness. The translation should state which represented elements are observed, inferred, reconstructed, simulated, or hypothetical.

Definition 9.31 (Representation–evidence map). *A representation–evidence map records the evidential sources, observation processes, and inferential bridges*

through which elements of an analytical representation receive empirical support, together with provenance and uncertainty for those elements.

The map can remain many-to-many. One observation can support several represented elements, and one represented element can require several evidence sources. An institutional relation may be supported by contracts, observed practice, interviews, correspondence, and resource flows. A historical turning point may require archival, temporal, and interpretive evidence. A field boundary can require administrative records together with observed interaction patterns.

Absence also requires an evidential map. The absence of a recorded relation can indicate genuine absence, unobserved interaction, archival loss, privacy restriction, changing classification, or measurement failure. Chapter 8 treated expected observability as central to inference from absence. Integrated design should therefore attach observation-system information to represented absence rather than coding missing traces automatically as zero.

Evidence architecture also determines what kinds of later validation are possible. If the project records only derived variables and discards source traces, reinterpretation becomes difficult. If provenance remains linked to representation elements, later researchers can revise coding, classification, or mechanism interpretation without reconstructing the entire evidential base.

Proposition 9.32 (Evidential addressability). *A representation becomes more auditable when each inferentially consequential element can be traced to the evidence, observation process, coding decision, and uncertainty through which it entered the design.*

Evidential addressability prepares method selection. Once the evidence architecture is specified, the project can ask which methodological operations are adequate to the question and representation.

9.3.4 Evidence to Method

Evidence-to-method translation concerns the selection and configuration of methodological operations that can transform the available evidence into warranted analytical results. Its role is to align method with question, representation, evidence quality, and inferential target. The presence of a dataset, archive, interview corpus, network, or simulation environment does not by itself determine the appropriate method.

Method selection should begin from the evidential task. Historical reconstruction may require source criticism, chronology, and process comparison. Interpretive inquiry may require contextual reading, coding, discourse analysis, or ethnographic interpretation. Relational inquiry may require network analysis, legal interpretation, qualitative reconstruction, or higher-order relational methods. Causal questions may require experimental, quasi-experimental, observational, comparative, or model-based strategies. Generative questions may combine process tracing, trajectory reconstruction, counterfactual analysis, simulation, formal modeling, and multiscale inquiry.

The same evidence can support different methods when the inferential target differs. Longitudinal administrative data can support descriptive trend analysis, event-

history analysis, causal comparison, stochastic transition estimation, or trajectory classification. Interview material can support interpretive reconstruction, mechanism tracing, institutional analysis, or object validation. The method should therefore be justified relative to the question rather than inferred from the data format.

Definition 9.33 (Method adequacy relation). A *method adequacy relation* specifies why a methodological operation is suitable for a defined question and evidence architecture, which assumptions make the operation informative, and which inferential components remain outside its reach.

Method adequacy includes feasibility. An idealized method can be theoretically attractive while being poorly matched to sample size, observation interval, archival coverage, field access, ethical constraints, computational resources, or institutional context. Integrated design should record these conditions because feasibility constraints can change the scope of the answer.

Method selection also creates transformations of evidence. Coding turns text into categories. Aggregation turns events into rates or periods. Statistical modeling turns observations into parameter estimates. Simulation turns rules and initial conditions into generated histories. Geometric embedding turns relational or feature structure into coordinates. Each transformation should remain documented because inference depends on the operations that intervene between original evidence and analytical result.

Multiple methods can be coordinated without being treated as mutually substitutable. One method can establish a temporal pattern, another can reconstruct a mechanism, and another can test sensitivity under alternative formalizations. The design should specify the role of each method and the inferential bridge among them. Chapter 8 developed this methodological plurality in detail; Chapter 9 turns it into an explicit project architecture.

Proposition 9.34 (Question-led method selection). *Method selection becomes more defensible when methodological operations are justified by the inferential requirements of the research question and the evidential architecture, with feasibility and assumption requirements recorded as part of the design.*

The method layer produces outputs that still require interpretation. The next translation concerns the movement from methodological result to inference.

9.3.5 Method to Inference

Method-to-inference translation concerns the interpretation of methodological outputs as evidence for substantive propositions. Its role is to prevent technical results from acquiring broader meaning than the method supports. A coefficient, coded theme, network statistic, simulated trajectory, formal theorem, or reconstructed process is an analytical result; an inference states what that result warrants about the research object.

The inferential bridge depends on assumptions that can be methodological, substantive, historical, or representational. A statistical estimate requires assumptions concerning measurement, model specification, selection, interference, and target population. A qualitative mechanism reconstruction requires assumptions concern-

ing source credibility, interpretive adequacy, case relevance, and completeness of the trace. A simulation requires assumptions concerning model structure, calibration, and the relation between encoded rules and the target process. A formal proof establishes consequences within a defined formal system and requires an additional bridge before those consequences become claims about an empirical field.

Definition 9.35 (Inferential bridge). An *inferential bridge* is the documented set of assumptions and interpretive steps through which a methodological result is taken to support a substantive proposition about the research object.

Inferential bridges can be local. A historical source may support the occurrence of an event strongly while providing weak evidence about motive. A network model may support a claim about topology while leaving relational meaning uncertain. A process trace may support an intermediate mechanism while leaving population prevalence open. Local bridges help prevent confidence in one part of an analysis from spreading automatically to another.

Inference should also preserve model dependence. If two plausible models yield different substantive interpretations, the design should report that dependence rather than selecting one result without qualification. If several formalizations support the same qualitative conclusion, the convergence can strengthen the claim while leaving magnitude or mechanism uncertain. Robustness architecture later in Chapter 9 will systematize this comparison.

The generative trajectory complex can support inferential localization by attaching evidence and interpretation to particular vertices, edges, faces, order relations, or alternative subcomplexes. A disputed edge need not invalidate a well-supported event vertex. A weakly supported higher-order face can remain provisional while lower-order relations remain intact. This modular structure mirrors the evidential and inferential decomposition developed in Chapter 8.

Proposition 9.36 (Inferential localization). *Research inferences become more revisable when support and uncertainty are attached to the specific propositions and representational components to which they apply, rather than being summarized only as global confidence in a model or narrative.*

Inference remains distinct from the final reported claim. The next stage concerns how inferential support is translated into language whose strength and scope match the available warrant.

9.3.6 Inference to Claim

Inference-to-claim translation concerns the construction of a reportable proposition whose language, scope, population, time horizon, scale, and attributional strength correspond to the available inference. Its role is to complete the theory-to-design chain without allowing rhetorical compression to erase uncertainty or conditionality accumulated earlier in the project.

A claim should identify what is being asserted, about which object or population, within which boundary and time horizon, and under which conditions. A descriptive claim can state an observed distribution. A relational claim can state the presence or transformation of a specified relation. A causal claim can state a defined contrast

under explicit assumptions. A generative claim can state contribution, enablement, mediation, co-generation, or stronger attribution where the evidential architecture supports it. A normative claim should state the evaluative standard and empirical premises on which it depends.

Claim construction should preserve scope reductions introduced during research. A project may begin with a broad theoretical proposition and end with a claim supported only in a particular institutional setting, historical period, population, or mechanism configuration. Such narrowing can represent successful research because the final claim is better matched to evidence. Integrated design should therefore retain the difference between the initial theoretical ambition and the warranted final statement.

Definition 9.37 (Claim contract). A *claim contract* records the proposition being reported together with its target object, population or field, temporal horizon, scale, conditions, attributional strength, evidential basis, uncertainty, and principal boundaries of generalization.

Claim contracts can also preserve disagreement. If two inferential routes support different interpretations, the report can state the common core and the unresolved alternatives. If a claim is robust to formalization but sensitive to boundary choice, that pattern belongs in the claim's scope. If a mechanism is strongly supported in one case while prevalence remains uncertain, the report should separate mechanism operation from broader frequency.

The claim layer therefore performs compression with accountability. A research article, policy report, or book chapter cannot reproduce every source trace and model diagnostic in the main prose. The project architecture can preserve the deeper chain in appendices, repositories, provenance records, or linked artifacts so that concise reporting does not require epistemic amnesia.

Proposition 9.38 (Proportional claim construction). A *final research claim is better aligned with the underlying design when its language and scope preserve the strongest inference that remains supported after uncertainty, alternative explanations, translation loss, and robustness results are taken into account.*

The completed chain from theory to claim still contains inevitable reduction. The next subsection makes that reduction a first-class object of research design.

9.3.7 Translation Loss

Translation loss concerns the information, distinction, ambiguity, context, or theoretical possibility that becomes unavailable or less visible as inquiry moves from concept to object, representation, evidence, method, inference, and claim. Its role is to make reduction visible without treating reduction as automatically defective. Research requires abstraction; the methodological problem is whether consequential losses are known, documented, and recoverable where possible.

Loss can occur at every stage. Concept-to-object translation can narrow a multidimensional concept to a tractable domain. Object-to-representation translation can suppress context, temporality, or higher-order structure. Representation-to-evidence translation can privilege observable traces over latent processes. Evidence-to-

method translation can aggregate, code, smooth, normalize, or otherwise transform source material. Method-to-inference translation can depend on assumptions that exclude alternative interpretations. Inference-to-claim translation can compress uncertainty and conditionality into concise prose.

Definition 9.39 (Translation-loss record). A *translation-loss record* documents the distinctions, information, contexts, or possible interpretations that are reduced, suppressed, aggregated, or left unresolved at a specified stage of theory-to-design translation, together with the consequences of that loss for inference and revision.

Translation loss can be acceptable when the omitted distinctions are irrelevant to the question or when preserving them would make analysis impossible without improving the inference. A high-frequency event record can be aggregated to monthly intervals when the mechanism operates slowly and the aggregation does not erase relevant transitions. A complex relational field can be represented through selected tie types when other relations are outside the question. The design should justify such reductions rather than aspiring to maximal informational retention in every component.

Some losses are consequential because they remove alternative pathways. Pairwise projection can erase higher-order relations. A single metric can collapse heterogeneous value forms. A binary treatment indicator can obscure adaptive intervention. A fixed network can conceal endogenous relation formation. A total temporal ordering can impose sequence where evidence supports only partial order. Such losses can change the substantive conclusion and therefore require explicit sensitivity or alternative representation.

Loss can also accumulate. Small reductions at several stages can produce a final claim whose relation to the original theory is much narrower than any one translation step suggests. Maintaining stage-specific records helps identify where this divergence entered. It also allows later researchers to revise one translation without repeating every earlier step.

Proposition 9.40 (Cumulative translation loss). *The distance between a theoretical concept and a reported claim can increase through several individually modest translation losses; recording those losses by stage improves the ability to diagnose, reinterpret, and revise the resulting research architecture.*

Translation-loss analysis also supports methodological pluralism. A second method or representation can sometimes recover distinctions suppressed by the first. Qualitative evidence can restore meaning lost in administrative coding. Historical reconstruction can restore sequence lost in cross-sectional data. Higher-order relational representation can restore configurations lost in pairwise projection. The aim is complementary access where the question warrants it, rather than redundant accumulation of methods.

The record of loss creates feedback to theory. If a theoretical term repeatedly resists defensible object construction or loses its defining distinctions under plausible representations, the concept itself may require revision.

9.3.8 Revision of Theoretical Terms

Revision of theoretical terms concerns changes to concepts prompted by the experience of translating them into research design. Its role is to make empirical and methodological friction productive for theory development. A theoretical term can be narrowed, differentiated, decomposed, related to another concept, or replaced when repeated design attempts show that its current formulation is too broad, ambiguous, unstable, or weakly connected to evidence.

Revision can begin with object construction. A broad concept such as dependency may separate into resource dependency, institutional dependency, epistemic dependency, or option-space dependency when the empirical configurations differ systematically. Capacity may require differentiation among individual, collective, institutional, epistemic, relational, and latent forms. Constraint may require separation among material, institutional, normative, relational, and emergent forms. Such differentiation can increase theoretical precision when it reflects recurring distinctions in the research field.

Representation can also motivate revision. A concept initially treated as dyadic may prove higher-order. A stable category may prove historically transformed. A scalar quantity may require a heterogeneous vector or relational representation. A smooth trajectory may require branching or partial order. Theoretical revision can therefore arise from representational mismatch rather than from direct empirical falsification alone.

Evidence can reveal hidden conditions. A concept may operate only under particular institutional supports, temporal horizons, or scale relations; methodological comparison can show that purportedly equivalent operationalizations capture different objects; and simulation or historical reconstruction can expose insufficiency or category change. Such findings can reshape the theoretical term.

Definition 9.41 (Theory-revision record). A *theory-revision record* documents the earlier theoretical term, the empirical or methodological difficulty encountered during design, the revised term or conceptual structure, and the consequences of that revision for objects, representations, evidence, methods, and prior claims.

Revision can remain local. A concept may work well in one domain and require modification in another. Integrated design should preserve domain-specific success rather than converting every local mismatch into a universal rejection. Conversely, repeated mismatch across domains can motivate broader theoretical reconstruction. The revision record makes that accumulation visible.

Theory revision also carries backward consequences. Earlier studies can require reinterpretation when a term changes, while retained data and provenance may remain usable under the revised concept. Translation records therefore support later re-epistemization without treating earlier coding as permanently authoritative.

Proposition 9.42 (Bidirectional theory–design development). *Theory and research design can develop recursively when theoretical concepts guide object construction and methodological choice while empirical, representational, and inferential difficulties feed back into revision of those concepts.*

9.4 Case Selection

This section develops case selection as the project-level design operation through which a research question is connected to a defensible set of empirical, historical, institutional, relational, or generative objects. Its role within Chapter 9 is to translate the theory-to-design architecture of Section 9.3 into a selection logic that can support the intended inference. The objective is to specify why particular cases enter a project, what inferential function each case performs, which features make that function plausible, and which selection effects remain as limitations. The discussion proceeds through eight case roles: typical, critical, deviant, historical, comparative, boundary, negative, and generative cases. The method is design-oriented and inferential. Case types are treated as roles within a research architecture rather than as intrinsic properties of empirical units.

Case selection appears earlier in the book within comparative relational inquiry, where the principal problem is whether cases can be compared without assuming that similarly named entities instantiate the same relations. The present section operates at a different level. Chapter 9 asks how an entire research project should choose cases after its question, theoretical objects, representations, evidence requirements, and intended claims have been specified. A case can therefore enter a project because it is typical of a defined population, unusually informative for a theoretical proposition, deviant from an established pattern, historically consequential, deliberately comparable with another case, located near a conceptual boundary, lacking a theoretically expected process, or especially rich for reconstructing generative dynamics. These rationales support different forms of inference.

A case is also distinct from a field, site, unit of observation, or data source. A project can define an institution as a case while gathering evidence across several organizational sites. A historical episode can be treated as a case while drawing on archives located in several jurisdictions. A relational configuration can be a case even when no single actor or place contains it. Conversely, one field site can contain several cases when the research design distinguishes multiple processes, organizations, relations, or trajectories within the same setting. Section 243 therefore addresses field selection separately. The distinction matters because access to a site does not by itself justify the inferential role assigned to a case.

Definition 9.43 (Case selection architecture). A *case selection architecture* is the documented relation among the research question, the theoretical or empirical object, the inclusion and exclusion criteria, the inferential role assigned to each case, the relevant comparison or reference set, the available evidence, and the limitations introduced by selection.

Definition 9.43 makes selection claim-relative. The same organization can function as a typical case for one question and a critical or boundary case for another. A historical transition can be selected as a deviant case relative to one expected trajectory and as a generative case when the objective is to reconstruct structural transformation. Case labels should therefore be justified by the design rather than attached permanently to the empirical object.

Selection also has a provenance dimension. Cases frequently become visible through archival availability, institutional access, prior literature, administrative

categories, personal networks, digital traces, public controversy, methodological convenience, or contingent encounter. These pathways can shape which cases appear researchable before theoretical selection criteria are applied. A project should distinguish the pathway through which a case became visible from the rationale through which it became analytically included. This distinction allows convenience, access, and discovery to remain visible without automatically disqualifying the case.

Proposition 9.44 (Inferential alignment of case selection). *Case selection supports a generative relational research design when the inclusion rationale is aligned with the intended inference, the reference set relevant to that rationale is stated, and the consequences of access, observability, boundary, and scale for the selected cases remain explicit.*

Proposition 9.44 supplies the organizing principle for the section. Representativeness is one possible objective among several. Mechanism discovery, theory refinement, boundary testing, historical reconstruction, negative-case analysis, and generative-process reconstruction can justify designs in which statistical typicality is secondary or irrelevant. The relevant standard is whether the selected case can perform the evidential and inferential role assigned to it.

9.4.1 Typical Cases

Typical cases are selected because they approximate a specified central or recurrent configuration within a defined reference set. Their role is to support inquiry into processes, relations, or mechanisms under conditions that are treated as comparatively ordinary for the research question. Typicality can be useful when the objective is to understand how a process operates in a common configuration, to build an empirically grounded baseline, or to assess whether a theoretical account developed from unusual cases also applies under recurrent conditions.

Typicality requires a reference set. A firm can be typical with respect to size distribution while atypical in ownership structure. A household can be typical in income while unusual in dependency relations. An institution can be formally ordinary while occupying an exceptional network position. The design should therefore identify the dimensions on which typicality is assessed and the population, field, period, or configuration against which that assessment is made.

Definition 9.45 (Typical-case profile). *A typical-case profile records the reference set, the dimensions used to assess typicality, the evidence supporting the placement of the case within that reference set, the dimensions on which the case remains atypical, and the inferential purpose served by selecting it.*

Typicality can be statistical, relational, institutional, historical, or processual. Statistical typicality can concern values near a distributional center. Relational typicality can concern recurrent configurations of dependence, coordination, or network position. Institutional typicality can concern common rule structures or organizational arrangements. Processual typicality can concern a recurrent sequence through which a capability, constraint, or relation develops. These forms can diverge, and the design should identify which one matters.

Typical cases can be especially valuable for mechanism refinement because they

reduce the risk that a mechanism appears important only because an extreme configuration magnifies it. At the same time, common configurations can conceal mechanisms whose operation becomes visible only under stress or transition. A typical case should therefore be selected because ordinary conditions are analytically relevant, rather than because typicality is assumed to be inherently superior.

Access conditions also matter. Easily accessible cases can appear typical because the reference set itself is shaped by visibility. Organizations with public records, populations covered by administrative data, or institutions willing to host researchers may be systematically different from less visible cases. A defensible typical-case rationale therefore requires attention to the relation between empirical centrality and observability.

9.4.2 Critical Cases

Critical cases are selected because their configuration provides unusually strong leverage on a theoretical proposition, mechanism claim, boundary condition, or design assumption. Their role is to concentrate inferential pressure. A case can be critical because a theory should plausibly operate especially clearly under its conditions, because competing explanations make sharply different expectations there, or because the case contains a strategically informative conjunction of conditions.

Criticality is relational to a proposition. An institutional reform may be critical for a theory of capacity generation when authorization, resources, and coordination are all unusually favorable, making persistent non-generation theoretically informative. A setting with unusually weak formal regulation may be critical for a theory that attributes relational stability primarily to legal enforcement. A historical episode can be critical when two candidate mechanisms imply different sequences or intermediate traces that can be investigated directly.

Definition 9.46 (Critical-case rationale). A *critical-case rationale* specifies the proposition under examination, the conditions that make the selected case especially informative for that proposition, the observations or process traces that would discriminate among relevant alternatives, and the scope of inference warranted by the result.

Critical cases require disciplined claim boundaries. Strong leverage on one proposition does not make the case representative of a wider population. A mechanism observed under unusually favorable conditions can establish plausibility or reveal process structure while leaving prevalence uncertain. Conversely, the absence of a predicted process in a critical configuration can place substantial pressure on a proposition without demonstrating that the proposition fails under every other configuration.

The design should also distinguish theoretical criticality from dramatic salience. Crises, famous institutions, legal landmarks, technological disruptions, and politically visible episodes can attract attention because they are consequential or well documented. They become methodologically critical only when the research question explains why their configuration yields unusual inferential leverage.

Critical-case selection can be combined with process tracing, counterfactual inquiry, intervention-based evidence, and formal modeling. The relevant contribution

lies in the alignment between the case configuration and the proposition being examined. A project can therefore use a small number of cases without treating case count as the primary measure of inferential strength.

9.4.3 Deviant Cases

Deviant cases are selected because they depart from a pattern, expectation, model prediction, typology, or recurrent trajectory that is otherwise sufficiently established to make the departure informative. Their role is to generate revision pressure. A deviant case can reveal omitted conditions, alternative mechanisms, measurement problems, category instability, changing boundaries, hidden heterogeneity, or transformation of the generative rule.

Deviance depends on an explicit expectation. A case is analytically deviant only relative to a model, comparison class, historical regularity, or theoretical structure. Labeling a case unusual without stating the expectation being violated provides little methodological leverage. The project should therefore retain the source of the expected pattern and the evidence that the selected case departs from it.

Definition 9.47 (Deviance profile). A *deviance profile* records the expected pattern, the reference set or model from which that expectation arises, the dimensions and magnitude of departure, possible observational or classificatory explanations, candidate generative explanations, and the revisions that the case could motivate.

Several forms of deviance are possible. Outcome deviance concerns an unexpected endpoint. Sequence deviance concerns an unusual order or timing of events. Relational deviance concerns a configuration that differs from recurrent network, dependency, or authority structures. Mechanism deviance occurs when a familiar outcome arises through an unexpected pathway. Structural deviance concerns transformation of boundaries, categories, or admissible transitions. Generative relational design benefits from distinguishing these forms because the relevant evidence differs.

Deviant cases are especially useful when the project preserves model failure rather than treating it as noise to be removed. An outlying observation can reflect measurement error, yet it can also disclose a neglected mechanism or a changing field. The design should evaluate observational explanations before assigning theoretical significance, while retaining enough provenance that later researchers can revisit the classification.

A deviant case can eventually cease to be deviant when theory changes. If repeated anomalies reveal a new process class, the reference model may be revised and the former anomaly reclassified. This possibility illustrates the recursive relation between case selection and theory development: cases are selected through theory, and some selected cases subsequently transform the theory that made them visible as deviations.

9.4.4 Historical Cases

Historical cases are selected because temporal formation, sequence, path dependence, institutional change, category transformation, or changing evidential regimes are central to the research question. Their role is to preserve historical process as

part of the object rather than treating time as a background index. A historical case can be an episode, period, institutional trajectory, sequence of reforms, technological transition, relational transformation, or longer lineage whose boundaries are justified by the generative problem.

Historical-case construction requires more than selecting an earlier date. The case should identify the process whose temporal development matters, the beginning and ending conditions, relevant prior conditions, and the continuity criteria that allow a changing object to remain part of the same case. These decisions can be especially difficult when institutions, categories, and evidence systems change during the period under study.

Definition 9.48 (Historical-case specification). A *historical-case specification* records the temporal boundaries, continuity and discontinuity criteria, relevant sequences and turning points, changing categories and institutions, evidential regimes, and the reason the selected historical interval is adequate for the intended inference.

Historical cases can be selected to reconstruct formation, compare alternative trajectories, study delayed generation, examine path dependence, locate structural transformation, or investigate changes in generative rules. A short event-centered window may be adequate for one question while obscuring the longer processes that made the event possible. A very long period can reveal institutional lineage while compressing local sequence. Temporal boundary choice is therefore an inferential decision rather than a neutral archival convenience.

The partially ordered generative trajectory complex developed in Chapter 8 provides one possible representation for historical-case design. Observed and inferred events can be distinguished, concurrency can be preserved, uncertain ordering can remain explicit, and higher-order process structures can be represented without forcing the history into a single smooth curve. The usefulness of this representation depends on whether event order and compositional structure are central to the historical question.

Historical cases also require attention to changing observability. Earlier periods can be represented through archives, correspondence, legal records, material traces, or retrospective testimony, while later periods can produce dense digital or administrative records. Differences in evidence density should remain distinct from differences in historical activity. Selection should therefore record whether a historical case is included partly because it is unusually well documented and how that documentation advantage affects inference.

9.4.5 Comparative Cases

Comparative cases are selected as a coordinated set because contrasts among them provide the inferential leverage required by the research question. Their role is project-level alignment of cases rather than comparison as an isolated analytical technique. A comparative set can be designed around similarities, differences, configurations, trajectories, institutions, historical periods, mechanisms, or generative outcomes, provided the dimensions of comparison are stated explicitly.

A project can compare cases that are similar on selected conditions and different

on a focal relation, cases that differ substantially yet exhibit a common process, or cases chosen to display several configurations of conditions and outcomes. Generative relational research can also compare pathways rather than endpoints. Two cases can reach similar observable states through different sequences, or diverge after sharing a substantial historical path. Such designs require case selection to preserve the temporal and relational dimensions relevant to the contrast.

Definition 9.49 (Comparative case set). A *comparative case set* is a coordinated selection of cases whose similarities, differences, configurations, or trajectories are specified in advance or iteratively documented as sources of inferential leverage for a defined comparative question.

Comparative selection depends on comparability, yet comparability need not be complete. Cases can be aligned on formal authority while remaining heterogeneous in enacted practice, or comparable in relational position while differing in cultural meaning. The design should identify which dimensions support comparison and retain the remaining differences as explicit remainders. Chapter 7 developed this relational discipline; Chapter 9 incorporates it into the architecture of the project as a whole.

Evidence symmetry deserves particular attention. A comparative design can appear balanced while one case is reconstructed through rich archival and qualitative evidence and another through a small number of standardized indicators. Differences in access can affect apparent mechanism richness, historical depth, and uncertainty. The selection record should therefore include evidence availability and identify where asymmetry constrains the comparative claim.

Comparative sets can also evolve. An initial pair can reveal a boundary case, deviant case, or negative case that becomes necessary for adjudicating among explanations. Iterative expansion can be methodologically productive when the reason for adding each case remains documented and the project distinguishes exploratory additions from cases specified before the main analysis.

9.4.6 Boundary Cases

Boundary cases are selected because they lie near the conceptual, empirical, institutional, relational, or generative boundary of a category or mechanism. Their role is to test where a research object ceases to remain adequately described by the current concept and where adjacent categories, processes, or representations become more appropriate. Boundary cases are therefore particularly important for theory-to-design translation because they reveal whether operational criteria preserve the intended distinctions.

A boundary can concern category membership, relation identity, institutional form, scale, temporal continuity, mechanism activation, or field membership. A hybrid organization can sit near the boundary between public and private institutional forms. A repeated interaction can approach the threshold at which an episodic tie becomes a durable relation. A capability can be present in a latent form while practical accessibility remains uncertain. A process can shift from ordinary parameter change toward transformation of the generative rule. Each case can help refine the corresponding conceptual boundary.

Definition 9.50 (Boundary case). A *boundary case* is a selected case whose classification, relational identity, mechanism status, scale placement, or temporal continuity is sufficiently close to a design boundary that examining the case can refine, split, relocate, or qualify that boundary.

Boundary cases can reveal problems created by sharp operational thresholds. A continuous or multidimensional phenomenon can be forced into binary categories for administrative or modeling convenience. Examining cases near the cutoff can show whether the threshold tracks a substantive transition or merely a coding decision. The design can then preserve graded membership, multiple dimensions, or alternative classifications where appropriate.

These cases also support ontological restraint. When an object can be represented plausibly in several ways, the boundary case can reveal which distinctions each representation preserves. A network representation can classify an interaction as a tie while an institutional analysis treats the relation as too weak to carry obligation. A legal classification can assign formal membership while ethnographic evidence shows ambiguous practical inclusion. The resulting tension can motivate representation plurality rather than premature categorical closure.

Boundary selection should remain distinct from convenience sampling near an available threshold. The case becomes informative when the research question explains why the boundary matters and which revision would follow from the evidence. Boundary cases therefore connect case selection directly to concept revision and category governance.

9.4.7 Negative Cases

Negative cases are selected because a theoretically relevant outcome, relation, mechanism, transition, or generative process is absent where some version of the current account makes that absence informative. Their role is to test sufficiency, enabling conditions, inhibition, blocked pathways, and rival explanations. The term concerns the relation between expectation and observation; it does not imply normative negativity.

Negative-case analysis requires an explicit expectation. A case in which an outcome is absent becomes informative only when the design specifies why the relevant conditions should have made the outcome, mechanism, or trace plausible. Section 235 distinguished failed, interrupted, blocked, inhibited, and dormant generation. Case selection can use those distinctions to identify negative cases with different inferential roles.

Definition 9.51 (Negative-case profile). A *negative-case profile* records the theoretically relevant process or outcome that is absent, the conditions that generated an expectation of its presence, the evidence supporting the absence judgment, alternative explanations involving observability or timing, and the proposition or mechanism that the case can evaluate.

A case with the source condition but without the expected outcome can reveal missing complements. A case with a proposed mechanism but no downstream manifestation can indicate delay, inhibition, measurement failure, or limited scope. A case with

similar initial conditions but a divergent trajectory can illuminate path dependence or early contingency. These designs can be especially valuable for generative inquiry because they test whether a proposed process is sufficient, conditional, or only one among several pathways.

Inference from negative cases requires strong observability discipline. The absence of a trace can reflect sparse records, inaccessible sites, changing categories, or an observation window that ends before delayed manifestation. A negative-case rationale should therefore include expected observability and the temporal horizon within which the relevant evidence would plausibly appear.

Negative cases can also arise iteratively. A project can begin with a positive case in which a mechanism appears plausible and then deliberately seek cases containing similar enabling conditions without the same result. This form of selection can refine the mechanism by identifying conditions that were initially treated as background. The design should record the sequential logic so that later additions are interpreted as theory development rather than as a pre-specified representative sample.

9.4.8 Generative Cases

Generative cases are selected because they provide unusually rich access to processes through which later capacities, constraints, relations, structures, option spaces, trajectories, or generative rules emerge or transform. Their role is to support reconstruction of generation rather than only estimation of association or comparison of endpoints. A generative case can be typical, critical, deviant, historical, comparative, boundary, or negative at the same time; the distinctive feature is the quality of access it provides to a generative process.

Generative richness can arise from temporal depth, dense process evidence, observable intermediate states, institutional records, relational traces, intervention history, natural variation, branching trajectories, or preserved evidence of unrealized alternatives. A case can be especially informative when it contains a visible transformation whose prior conditions and downstream consequences are both sufficiently documented to reconstruct how the change unfolded.

Definition 9.52 (Generative case). A *generative case* is a selected case whose evidence permits unusually detailed reconstruction of how specified conditions, relations, mechanisms, sequences, and structural changes contribute to later states or possibilities across a defined temporal and scalar horizon.

Generative cases should not be selected only because the outcome is dramatic. A highly visible transformation can have poor evidence concerning intermediate process, while a modest institutional change can provide exceptional access to mechanisms, feedback, capacity generation, and rule transformation. The relevant criterion is process addressability. The project should identify which parts of the generative claim can actually be reconstructed and which remain speculative.

The partially ordered generative trajectory complex can support this design by recording why the case is generatively informative. Event vertices can carry evidence provenance, typed edges can represent candidate direct couplings, higher-order faces can represent process or structural coherence, and partial order can preserve concur-

rency and uncertain sequence. Alternative completions can remain visible where the record does not uniquely determine the history. The representation is optional; the design principle is that generative cases preserve the structure of becoming rather than only initial and final states.

Generative-case selection also has a risk of selection on successful manifestation. If cases are chosen only because a visible transformation occurred, the design can overstate mechanisms associated with realized pathways and underrepresent failed, blocked, dormant, or alternative processes. A stronger architecture can therefore combine generative cases with negative, deviant, or boundary cases. Such combinations permit the project to compare active generation with non-generation, alternative sequence, or transformed conditions.

Proposition 9.53 (Plural case roles). *A case can legitimately perform several selection roles when each role is separately justified and the project preserves the inferential contribution and limitation associated with each role.*

Proposition 9.53 prevents the typology from becoming a partition. A historical case can also be critical; a boundary case can also be deviant; a comparative set can contain typical and negative cases; and a generative case can supply mechanism-rich evidence while remaining unrepresentative of prevalence. Recording these overlapping roles produces a more accurate account of why the case is present in the design.

Case selection therefore completes an important transition in Chapter 9. Research-question architecture specifies the kinds of inference sought, and theory-to-design translation identifies the objects and evidence that can support those inferences. Case selection then determines where those objects and processes will be investigated and what inferential work each selected case is expected to perform. The next design layer concerns the field in which observation, access, interaction, and evidence collection occur. Section 243 develops field selection through field definition, accessibility, relevance, heterogeneity, comparison, boundary, evolution, and exit.

9.5 Field Selection

This section develops field selection as the design operation through which a research project specifies the empirical environment in which its objects, relations, processes, and evidential traces can become accessible. Its role within Chapter 9 is to extend case selection from the choice of inferentially useful cases toward the environments through which those cases and processes can be observed, encountered, documented, compared, and followed through time. The objective is to specify how fields are defined, accessed, evaluated for relevance, characterized for heterogeneity, compared, bounded, tracked as they evolve, and exited responsibly. The discussion proceeds through eight components: field definition, accessibility, relevance, heterogeneity, comparison, boundary, evolution, and exit. The method is design-oriented and relational. A field is treated as a study-relative empirical environment rather than as a self-evident geographical location.

Case selection and field selection perform different functions. Section 9.4 identified cases according to the inferential roles they can perform. Field selection identifies the environments through which the project can gain evidence about those cases and

about processes that may extend beyond any single case. One case can span several fields, such as an organization whose formal decisions, operational practices, digital systems, and historical archives are distributed across distinct sites. One field can contain several cases, such as a regulatory domain in which multiple organizations, disputes, institutional episodes, or relational configurations can be studied comparatively. The distinction matters because an apparently strong case design can remain empirically weak when the selected field provides poor access to the process that gives the case its inferential value.

The term *field* is used here in a design sense. It can refer to a physical site, an institutional domain, an organizational setting, a digital environment, an archival domain, a professional arena, a relational network, a policy setting, or a historically delimited environment within which the research object becomes empirically addressable. A project can also define a composite field whose evidence is distributed across several of these environments. This usage remains distinct from any specific sociological theory of fields and from the mathematical field representations discussed in Section 2.2.2. The local meaning should therefore be stated directly whenever ambiguity is possible.

Definition 9.54 (Research field). A *research field* is a study-relative empirical environment within which specified actors, relations, institutions, practices, documents, technologies, events, or processes can be observed or reconstructed through identifiable channels of access across a defined spatial, institutional, relational, digital, or temporal scope.

Definition 9.54 places access and scope inside field construction. A field does not become methodologically adequate because it contains the nominal object of interest. The project should also establish which parts of the relevant process become visible there, which remain outside the selected environment, and which observational channels connect the field to the intended claim. Field selection is therefore an evidential design decision as well as a logistical one.

9.5.1 Field Definition

Field definition specifies the empirical environment that the project intends to enter, observe, reconstruct, or otherwise use as a source of evidence. Its role is to translate a theoretical or research object into a bounded empirical domain without assuming that administrative, geographical, organizational, or technological boundaries automatically coincide with the process under study. A defensible field definition identifies what is included, which relations or processes make the inclusion relevant, what temporal horizon is covered, and which forms of evidence can plausibly emerge from the selected environment.

A field can be defined through several dimensions. Spatial definition concerns location and movement across places. Institutional definition concerns organizations, jurisdictions, procedures, and formal authority. Relational definition concerns interaction networks, role structures, dependencies, or communication pathways. Digital definition concerns platforms, databases, interfaces, technical systems, and online environments. Historical definition concerns the temporal period during which a particular configuration, category, or institutional arrangement existed. These dimen-

sions can coincide, but they often diverge. An organization can occupy several physical sites while sharing one institutional field; a digital platform can connect actors across jurisdictions; an archival field can reconstruct interactions among institutions that no longer exist in their earlier form.

Definition 9.55 (Field-definition profile). A *field-definition profile* records the empirical domain selected for inquiry, the objects and relations that connect the domain to the research question, the spatial or institutional scope, the temporal horizon, the principal observation channels, and the exclusions that materially affect interpretation.

The profile should preserve the distinction between the field and the research object. A field can contain large amounts of activity that fall outside the project, while a research object can extend beyond the field currently selected for observation. For example, a project on institutional trust can observe formal meetings, internal documents, public communication, and participant interaction within one organizational field while recognizing that trust trajectories also depend on prior experiences, external institutions, or wider political and economic conditions. The field provides an empirical window rather than a complete container of the phenomenon.

Field definition also shapes what can become evidence. A narrowly defined organizational field can provide high-resolution evidence about procedures and interaction while offering limited leverage on wider structural conditions. A broad multi-institutional field can reveal cross-organizational patterns while reducing observational depth. A historical field can extend temporal depth while increasing uncertainty about missing records. These tradeoffs should be documented as design properties rather than discovered only during interpretation.

The field-definition process can remain provisional at the beginning of a project. Early encounters may reveal that a nominally central site provides weak access to the relevant process, while an adjacent environment contains the actual decision pathway, record system, or relational interface. Revision is therefore compatible with disciplined design when the reason for the change and its inferential consequences are recorded.

9.5.2 Field Accessibility

Field accessibility concerns the channels through which the researcher can obtain legitimate and sufficiently informative contact with the selected empirical environment. Its role in research design extends beyond practical entry. Accessibility determines which actors can be approached, which records can be inspected, which interactions can be observed, which computational systems can be queried, and which temporal portions of the process can be reconstructed. The design should therefore treat access as a structured property of the field rather than as a binary condition.

Several forms of access can coexist. Physical access concerns entry to sites and participation in activities. Institutional access concerns permissions, organizational sponsorship, gatekeeping, and role authorization. Documentary access concerns records, archives, internal communications, and data retention systems. Relational access concerns the ability to reach actors occupying different positions within the field rather than only those closest to the researcher. Technical access concerns

data formats, APIs, logging systems, computational infrastructure, and the ability to reproduce data transformations. Temporal access concerns whether earlier phases of the process remain reconstructable through archives, recollection, or retained traces.

Definition 9.56 (Field-access profile). A *field-access profile* specifies the channels through which evidence can be obtained from a selected field, the actors or institutions that mediate those channels, the portions of the field that remain weakly accessible, and the likely consequences of this access structure for the research claim.

Access mediated through a single gatekeeper can create a distinctive evidence architecture. The gatekeeper may determine which participants become visible, which documents can be inspected, and which parts of organizational practice remain hidden. Such mediation does not invalidate the field, but it becomes relevant to selection and later interpretation. The project can respond through complementary evidence channels, explicit access limitations, or comparison with other fields where different positions are observable.

Accessibility also has distributional structure. Senior personnel may be easy to interview while frontline workers, affected communities, external partners, or former members remain difficult to reach. Digital logs may provide dense traces of platform activity while excluding off-platform coordination. Public archives may preserve formal decisions more reliably than informal disagreement. A field with high data volume can therefore have low access to the process most relevant to the generative question.

Proposition 9.57 (Access adequacy). *Field accessibility contributes to design adequacy when the available access channels provide evidence for the inferential components that the field is expected to support, with remaining access asymmetries preserved as explicit limitations.*

Proposition 9.57 separates access quantity from access adequacy. Many observations from the same position can leave a mechanism poorly identified, while a smaller set of strategically located observations can reveal the process linking stages or actors. Field selection should therefore evaluate whether the access structure matches the evidential role assigned to the field.

Access can also change during research. Permissions can expand, expire, or be withdrawn; organizations can reorganize; participants can leave; technical systems can change; archives can become newly available. These developments belong to field evolution as well as accessibility and should be recorded so that the evidential conditions of different project phases remain visible.

9.5.3 Field Relevance

Field relevance concerns the correspondence between a selected empirical environment and the research question, theoretical object, mechanism, historical process, or normative problem that the project intends to investigate. Its role is to prevent convenience, prestige, visibility, or data abundance from substituting for design fit. A field is relevant when it provides access to distinctions that matter for the intended

inference.

Relevance can arise through different pathways. A field can contain the principal mechanism of interest. It can expose a critical transition or boundary. It can preserve unusually rich historical evidence. It can contain variation in conditions needed for comparison. It can make a normally hidden relational process visible. It can support observation of how formal rules become enacted in practice. It can provide evidence about absence, inhibition, or failed generation. These forms of relevance should be linked directly to the project architecture rather than treated as general virtues of the site.

Definition 9.58 (Field-relevance relation). A *field-relevance relation* identifies the inferential component of a research design that a selected field can address and specifies the empirical features of the field that make that contribution plausible.

A project can therefore use several fields for different reasons. One field can provide process-rich evidence about mechanism, another can offer longitudinal data, and a third can supply a contrasting institutional environment. Relevance remains component-specific. A field that is excellent for observing implementation can provide limited leverage on historical formation; an archive can provide historical sequence without direct access to contemporary meaning; a digital platform can reveal interaction topology while leaving off-platform interpretation weakly observed.

Field relevance should also be distinguished from substantive importance. A socially or politically important environment can still be poorly aligned with the specific research question. Conversely, a modest or less visible field can be methodologically valuable because its records, variation, or process transparency make a difficult generative relation observable. Selection should therefore explain the inferential value of the field without relying on status or salience alone.

Relevance can change as the research question evolves. A field selected for a descriptive question can become insufficient after the project shifts toward mechanism or generative attribution. A newly identified relation can require access to another institutional layer or historical period. Recording these changes protects the project from silently continuing to use a field whose original relevance no longer matches the revised design.

9.5.4 Field Heterogeneity

Field heterogeneity concerns internal variation within the selected empirical environment. Its role is to prevent the field from being treated as a homogeneous unit when actors, institutions, practices, technologies, historical layers, or relational positions differ in ways that affect the research object. Heterogeneity can be a source of analytical leverage, a source of bias, or both.

Internal variation can appear across organizational roles, geographic sub-sites, demographic groups, institutional units, technical systems, legal statuses, network positions, historical cohorts, or stages of a process. A field defined as one organization can contain conflicting subcultures and unequal authority. A policy field can contain agencies operating under different implementation regimes. A digital environment can contain communities with different norms and platform affordances. An archive

can overrepresent periods or actors whose records were preserved more systematically.

Definition 9.59 (Field-heterogeneity map). A *field-heterogeneity map* records the dimensions of internal variation that can alter observation, mechanism, accessibility, interpretation, or generative effect within a selected field, together with the project's strategy for representing those differences.

Heterogeneity matters for sampling within the field. If access concentrates on one subgroup, the project can inadvertently generalize a local perspective to the field as a whole. If an institutional process differs across departments, an aggregate description can conceal important variation in mechanism. If one network position mediates most information flow, a field-level average can miss the relational architecture that generates the observed pattern. The map therefore guides within-field evidence collection as well as later inference.

Heterogeneity can also support internal comparison. Differences among sub-sites, roles, or historical periods can provide leverage on enabling conditions, implementation differences, or mechanism variation without requiring a wholly separate field. The project should state when such within-field contrasts are analytically comparable and when they represent qualitatively different environments that deserve separate field status.

Variation in observability should remain separate from substantive heterogeneity. Some actors may generate more records because their work is formalized; others may be less visible because their interactions occur informally. Apparent heterogeneity in evidence density can therefore reflect the observation system rather than the process itself. Field design should preserve that distinction.

9.5.5 Field Comparison

Field comparison coordinates evidence across two or more empirical environments whose similarities and differences contribute to the research design. Its role is to extend comparative reasoning from cases to the environments in which cases and processes become observable. Comparative field design can reveal how institutions, access structures, relational configurations, historical conditions, or measurement systems shape the process being studied.

Fields become comparable through specified dimensions rather than through generic similarity. A project can compare two regulatory environments because they implement a shared formal rule under different institutional conditions. It can compare two organizational fields because they occupy similar functional positions while differing in governance structure. It can compare historical periods because a common process remains identifiable across changing categories. The relevant dimensions should be stated before the comparison is interpreted.

Definition 9.60 (Comparative-field profile). A *comparative-field profile* records the dimensions on which selected fields are treated as comparable, the dimensions on which their differences are analytically relevant, the evidence channels available in each field, and the asymmetries that constrain cross-field inference.

Evidence symmetry is rarely complete. One field can provide interviews and inter-

nal documents while another provides only public records. One historical field can have dense archives while another has substantial gaps. One digital environment can expose interaction logs while a comparable offline setting relies on observational notes. These differences do not automatically preclude comparison, but they should be incorporated into the comparative design so that field differences are not confused with measurement differences.

Comparative field selection can also improve mechanism analysis. If a proposed mechanism appears under several field configurations, the comparison can identify which conditions are stable and which vary. If similar outcomes arise through different mechanisms, the fields can reveal equifinality. If the same mechanism produces different downstream effects, differences in field structure can become candidate moderators or constraints.

Field comparison should preserve field-specific remainder. A common analytical vocabulary can support comparison while still allowing each field to contain institutions, meanings, or historical features that do not translate cleanly into the shared representation. Chapter 7 treated preserved remainder as important in relational comparison; the same discipline applies at the field level.

9.5.6 Field Boundary

Field boundary concerns the design decision through which the project determines where a selected empirical environment begins, ends, or changes analytical status. Its role is to make inclusion and exclusion explicit, especially where relations, actors, data, and institutional processes cross nominal administrative or spatial boundaries. Field boundaries are often porous, layered, and scale-dependent.

A field can have several overlapping boundaries. A legal boundary can differ from an organizational boundary. A communication network can extend beyond the physical site. A digital platform can connect actors whose formal institutional affiliations lie elsewhere. A historical process can begin before the period for which reliable records exist. A supply or knowledge relation can connect an apparently local field to geographically distant organizations. Field selection should therefore specify which boundary matters for which inferential purpose.

Definition 9.61 (Field-boundary profile). A *field-boundary profile* records the spatial, institutional, relational, digital, temporal, and evidential boundaries relevant to a selected field, together with the rule used to determine which objects and processes remain inside the active research domain.

Boundary decisions can change the apparent mechanism. A study restricted to formal organizational members can miss external contractors or community actors who carry critical relations. A jurisdictional boundary can exclude upstream institutions that determine practical constraints. A temporal boundary beginning at policy implementation can hide the political and organizational process that made implementation possible. These are design effects rather than neutral facts about the field.

Field boundaries can also be nested. A local site can belong to an organizational field, which belongs to a regulatory field, which sits within a wider economic or political environment. Multiscale design can preserve these nested domains without

requiring the project to observe each level with equal depth. The important requirement is to state which boundary supports each claim and where cross-boundary influence enters the analysis.

The partially ordered generative trajectory complex can assist when field boundaries change through time. Events can be annotated with field membership, edges can cross field boundaries, and higher-order faces can represent processes that couple several fields. The representation is optional, but the design principle is important: cross-boundary relations should remain visible when they are generatively relevant.

9.5.7 Field Evolution

Field evolution concerns changes in the empirical environment during the research period or across the historical horizon reconstructed by the project. Its role is to prevent the field from being treated as a static container when organizations reorganize, boundaries shift, categories change, technologies are introduced, access arrangements change, or relevant actors enter and leave. A field can therefore possess a trajectory of its own.

Field evolution can alter both the target process and the observation system. A new information system can change organizational coordination while also changing which interactions generate records. A reform can reorganize authority and simultaneously redefine administrative categories. A platform update can alter user behavior and the available data structure. A change in leadership can modify access to the field while also changing the institutional process being studied. These dual effects should be recorded separately where possible.

Definition 9.62 (Field-evolution record). A *field-evolution record* documents changes in the composition, boundaries, institutions, technologies, categories, access channels, and evidential infrastructure of a selected field across the research horizon, together with the implications of those changes for comparability and inference.

A field-evolution record supports periodization. If the field changes sufficiently, data collected before and after the transition may represent different institutional or relational configurations. Combining them without qualification can create artificial continuity. Conversely, treating every change as a new field can fragment a process that retains substantial continuity. The design should identify which transformations alter the meaning of the field for the research question.

Field evolution also interacts with researcher presence. Interviews, workshops, data requests, interventions, or repeated observation can alter awareness and practice within the field. The magnitude of this effect varies across designs, but the project should preserve any plausible route through which research activity becomes part of field evolution. Section 231 examined action-generated evidence in intervention-based inquiry; a related concern applies whenever observation changes the environment being observed.

The trajectory-complex framework can represent field evolution through field-typed events, boundary changes, relation formation or dissolution, institutional transformations, and revised provenance. Alternative periodizations can remain

visible where the historical record supports more than one reconstruction. This makes field evolution compatible with the wider Chapter 8 methodology without converting field selection into a formal requirement.

9.5.8 Field Exit

Field exit specifies how active empirical engagement with a selected field is concluded, transferred, suspended, or converted into a different research relation. Its role is to make the end of field engagement part of the research design rather than an administrative event occurring after evidence collection. Exit affects data custody, participant expectations, ongoing obligations, recontact, interpretation, and the temporal boundary of the study.

Field exit can occur for several reasons. The planned observation period can end. The project can reach evidential saturation for its current question. Access can expire. The field can transform so substantially that the original design loses correspondence with the environment. Ethical or safety concerns can require withdrawal. A project can also move from active field engagement toward archival, computational, or comparative work while retaining limited channels for clarification or member checking.

Definition 9.63 (Field-exit protocol). *A field-exit protocol* records the conditions that conclude or transform active field engagement, the disposition and preservation of collected materials, remaining obligations to participants or institutions, recontact arrangements where applicable, and the inferential consequences of the chosen exit point.

Exit should correspond to the evidence architecture rather than to convenience alone. Ending observation before a delayed process becomes visible can leave a generative question underdetermined. Continuing engagement indefinitely can consume resources without materially improving the claim. A design can therefore specify substantive exit criteria, such as coverage of key process stages, completion of planned comparison, stabilization of an evidence gap, or transition to a new field phase.

The exit point also becomes part of the temporal horizon. Claims about persistence, delayed effects, or structural transformation should remain bounded by the period actually observed or reconstructable after exit. Later developments can motivate follow-up research without being silently incorporated into the original evidential base.

Field exit has relational and ethical dimensions. Participants can reasonably understand the research relationship differently from the research team, especially after prolonged engagement. Clear communication about the end of active collection, future contact, use of records, confidentiality, and publication can reduce ambiguity. Where the project has created outputs, coding schemes, documentation, or other resources relevant to the field, their disposition should be stated consistently with consent, governance, and data-protection commitments.

Proposition 9.64 (Field-selection traceability). *A field-selection design becomes more inspectable when field definition, access, relevance, heterogeneity, comparison, boundary, evolution, and exit are recorded as linked design decisions whose revisions propa-*

gate to evidence, method, and claim scope.

Proposition 9.64 summarizes the role of the section. Field selection determines where the project can encounter the empirical process, which parts become visible, which positions remain weakly observed, how comparison is structured, and where the research relation begins and ends. These decisions therefore shape the data architecture that follows. Section 244 develops that next layer by specifying primary, secondary, documentary, archival, relational, longitudinal, and computational data together with provenance and preservation requirements.

9.6 Data Architecture

Data architecture specifies how evidence-bearing materials enter, move through, and remain recoverable within an integrated Generative Relational research project. Its role in Chapter 9 is to connect the field and case architecture of Sections 9.4–9.5 with the representational and methodological architecture developed in the sections that follow. The objective is to distinguish major data families by provenance, production conditions, temporal structure, relational form, and computational status while preserving the transformations that connect raw materials to analytical evidence. The discussion proceeds through primary, secondary, documentary, archival, relational, longitudinal, and computational data, followed by data provenance and data preservation. The mode of argument is methodological and architectural: data are treated as historically and institutionally produced research materials whose evidential role depends on how they were generated, selected, transformed, linked, and retained.

A data architecture therefore extends beyond a list of files or variables. A project can draw on interviews, observations, administrative records, legal texts, archives, network traces, repeated measurements, simulation outputs, and derived computational objects at the same time. These materials can differ in what they record, who produced them, why they were produced, which categories they presuppose, what transformations they have undergone, and which portions of the target process they make visible. The architecture should preserve those differences while also specifying the interfaces through which several data forms can support one research question.

The distinction between data and evidence remains important. A record can become evidence for one claim and remain largely irrelevant to another. A network edge extracted from administrative transactions can provide relational evidence when the extraction rule corresponds to the relation under study; the same edge can be weak evidence when the administrative event only imperfectly manifests the substantive relation. A historical document can strongly support the date and wording of a formal decision while providing limited access to how that decision was enacted. Data architecture therefore concerns both material organization and epistemic interpretation.

Definition 9.65 (Generative relational data architecture). A *generative relational data architecture* is a documented system for acquiring, generating, transforming, linking, versioning, interpreting, preserving, and revising research data in relation to specified objects, questions, representations, evidential roles, provenance conditions,

temporal structures, and inferential claims.

Definition 9.65 makes the relation between data and research design explicit. The architecture can be simple when one source directly addresses a narrow question, or elaborate when several data families must be aligned across scales, institutions, periods, or representational forms. Complexity is warranted by the research problem rather than by an independent preference for large or heterogeneous datasets.

Proposition 9.66 (Data-role explicitness). *A data architecture becomes more auditable when each data source is assigned an explicit evidential role, production context, transformation history, and relation to the claims for which it is used.*

Proposition 9.66 guides the nine components below. The same material can support several roles, and several materials can support the same claim, yet those overlaps should remain traceable rather than disappearing inside a merged dataset.

9.6.1 Primary Data

Primary data are generated or collected by the research project through direct engagement with the selected field, cases, instruments, or interventions. Their role is to provide project-specific access to phenomena that existing records represent incompletely, indirectly, or at an unsuitable resolution. The objective is to specify how direct collection is connected to the research question, how the presence of the researcher or instrument shapes the data-generating process, and which portions of the resulting material are observations, elicited responses, measurements, or action-generated traces. The method begins from the required evidential function and designs collection around that function.

Primary data can include interviews, observation, ethnographic field notes, surveys, experiments, measurements, diaries, photographs, recordings, sensor streams, direct network elicitation, field interventions, and other project-generated records. These forms differ substantially in how they are produced. An interview is co-produced through interaction between researcher and participant. A sensor record depends on placement, calibration, sampling frequency, and preprocessing. An experiment generates observations under a designed intervention structure. A field note combines observation with researcher selection and interpretation. Data architecture should therefore record production conditions at the level required to evaluate the corresponding claims.

A useful primary-data design begins with evidential need rather than instrument availability. If the question concerns the meaning actors assign to an institutional classification, interviews or interpretive observation can be relevant. If it concerns temporal response to a perturbation, repeated measurement can be more appropriate. If it concerns higher-order relational coordination, data collection may need to record group interactions rather than only independent individual responses. The instrument should follow the object and question rather than define them retroactively.

Definition 9.67 (Primary-data production profile). *A primary-data production profile records the data-generating encounter, participants or units, instrument or observation procedure, temporal and spatial conditions, researcher involvement, sampling*

or recruitment logic, transformation steps, and known sources of uncertainty for a primary-data stream.

Primary data also have interaction effects. Questions can change what respondents articulate. Observation can alter behavior. Repeated measurement can induce learning or fatigue. Interventions can transform the field whose later state is being measured. These effects are not uniformly defects; some are substantively informative. Their relevance depends on whether the project treats the data-generating interaction as part of the phenomenon or as a source of distortion that should be minimized or modeled.

The architecture should preserve refusals, nonresponse, attrition, inaccessible units, and other participation boundaries where they affect interpretation. A dataset consisting only of completed observations can hide the relational and institutional processes that determine who becomes observable. Recruitment and missingness can therefore be part of the primary-data architecture rather than merely a statistical cleaning issue.

Proposition 9.68 (Primary-data alignment). *Primary-data collection gains methodological adequacy when the data-generating procedure is designed around a specified evidential role and when the effects of recruitment, instrumentation, researcher participation, and field interaction remain visible in interpretation.*

The primary-data profile provides the basis for later provenance and preservation. Without it, a highly detailed dataset can remain weakly interpretable because the conditions under which its observations came into existence are no longer recoverable.

9.6.2 Secondary Data

Secondary data are materials generated outside the current research project and subsequently reused for a new analytical purpose. Their role is to extend temporal, population, institutional, or comparative reach while reducing the need to reproduce data-generating processes that already exist. The objective is to evaluate the correspondence between the original production purpose and the present research object, identify transformations introduced by reuse, and preserve the institutional history embedded in categories, sampling frames, coding rules, and access conditions. The method combines source evaluation, metadata reconstruction, category analysis, and sensitivity to changes in data-generating systems.

Secondary data can include administrative databases, census products, survey archives, transaction records, organizational statistics, platform traces, previously collected research datasets, and other structured data generated for purposes outside the present project. Their apparent readiness for analysis can conceal substantial interpretive work. Administrative data record what an institution was organized to see. Survey variables encode previous theoretical and practical choices. Platform traces reflect system architecture and user behavior under changing technical rules. A variable name can remain stable while its meaning changes through policy, measurement, or classification reform.

The central design question is correspondence. Researchers should identify how closely the available unit, variable, temporal resolution, and category structure map

onto the theoretical object developed in Section 9.3. Strong correspondence can justify direct use. Partial correspondence can require recoding, triangulation, or explicit residual uncertainty. Weak correspondence can make the dataset unsuitable even when it is large and technically accessible.

Definition 9.69 (Secondary-data correspondence profile). A *secondary-data correspondence profile* documents the original purpose, producing institution, population or coverage frame, measurement and coding rules, temporal resolution, access conditions, known revisions, and degree of correspondence between the inherited data structure and the present research object.

Secondary-data reuse can also create historical discontinuities. An agency can re-define eligibility, merge administrative categories, alter reporting incentives, change software systems, or improve detection. Apparent changes in the data can therefore arise from transformation of the recording architecture as well as transformation of the target process. Longitudinal and historical analyses should preserve these changes rather than forcing the series into artificial continuity.

Reuse can provide powerful comparative leverage when the same data-generating system covers several cases or periods. Yet apparent standardization does not guarantee substantive equivalence. Local implementation, reporting incentives, missingness, or institutional capacity can differ. Comparative use therefore benefits from local metadata and institutional knowledge in addition to common variable labels.

A secondary-data architecture should retain source versions and the transformations performed locally. Reproducibility becomes difficult when a project overwrites downloaded files, silently corrects values, or retains only the final analysis table. The inherited material and the project-generated transformation history should remain distinguishable.

9.6.3 Documentary Data

Documentary data consist of texts, records, media, and formal artifacts produced within the institutional, legal, organizational, scientific, political, economic, or cultural processes under study. Their role is to provide access to manifested classifications, decisions, arguments, rules, narratives, commitments, and recorded events. The objective is to distinguish the document as an empirical artifact from the underlying relations or processes it is used to investigate, while preserving authorship, audience, institutional position, production context, and later circulation. The method is interpretive and provenance-sensitive.

Documentary data can include legislation, contracts, policy documents, minutes, correspondence, reports, manuals, technical standards, news articles, websites, institutional statements, research outputs, financial disclosures, judicial texts, and many other artifact types. A document can record a decision, justify it, communicate it, contest it, or retrospectively reconstruct it. These functions affect how the document enters inference. A policy document can strongly establish formal wording while remaining limited evidence of implementation. Meeting minutes can reveal authorized records while omitting informal disagreement. Public statements can disclose institutional positioning without exhausting internal motives.

Definition 9.70 (Documentary-evidence profile). A *documentary-evidence profile* records a document's producer, institutional position, date or period, intended and actual audiences where known, genre, production purpose, circulation history, preservation status, and the specific evidential propositions for which the document is used.

Documentary analysis benefits from preserving internal structure. Headings, appendices, revisions, marginalia, signatures, metadata, hyperlinks, referenced standards, and attachments can carry evidential meaning. Converting a document into plain extracted text can improve search while discarding layout, version history, or relational context. The data architecture can therefore retain both an analysis representation and a higher-fidelity source representation when those features matter.

Documents also form relations among one another. A regulation cites a statute, an internal memo responds to a report, a later policy revises an earlier standard, and a public statement can quote or reframe another actor's language. These connections can become relational data in their own right. The documentary and relational architectures should therefore interface rather than treating text as isolated content.

Generated or machine-transformed text requires additional annotation. Transcription, translation, summarization, entity extraction, embedding, or automated classification can create useful computational representations, yet these derived objects should remain linked to their source documents. The analytical convenience of transformed text does not replace the provenance needed to revisit interpretation.

9.6.4 Archival Data

Archival data are documentary, material, or digital records preserved through historically situated selection, organization, description, restriction, and loss. Their role is particularly important for reconstructing trajectories, institutions, classifications, and unrealized possibilities across time. The objective is to treat archival organization as part of the evidence environment rather than assuming that preserved records transparently mirror the past. The method combines source criticism, collection-level analysis, temporal reconstruction, and explicit attention to archival silence and preservation history.

An archive differs from an arbitrary collection of old documents because records have passed through processes of retention, disposal, classification, arrangement, cataloguing, access control, digitization, and sometimes later reorganization. These processes shape what becomes discoverable. Institutional archives can preserve formal decisions more systematically than informal practices. Personal collections can overrepresent correspondents who retained letters. Digitized collections can make selected materials disproportionately visible relative to uncatalogued holdings.

Definition 9.71 (Archival-access profile). An *archival-access profile* records collection origin, custody and preservation history, arrangement system, catalogue structure, access restrictions, digitization status, known losses or gaps, temporal coverage, and the relation between the surviving record and the historical process being reconstructed.

Archival silence should be localized where possible. The absence of a document

can reflect non-production, non-preservation, restricted access, cataloguing failure, destruction, or search failure. These possibilities have different implications. The absent-generativity methods developed in Chapter 8 provide a useful parallel: inference from absence becomes informative only when expected observability has been specified. Archival research likewise benefits from stating what record would plausibly have existed, through which preservation pathway, and with what probability of present discovery.

Temporal order can be reconstructed from archival traces without forcing all events into exact dates. A record can establish that one decision preceded another, that two processes overlapped, or that an institutional change occurred within an interval. The partially ordered generative trajectory complex provides one representation for retaining such relations when precise chronology is unavailable.

Archive construction can itself become an object of inquiry. Decisions about whose records are preserved, which categories organize retrieval, and what remains publicly accessible can shape later knowledge. Data architecture should therefore distinguish using an archive as evidence from studying archival practices as part of the target generative process.

9.6.5 Relational Data

Relational data record connections, interactions, dependencies, memberships, transfers, co-occurrences, authority relations, or other structured links among analytically defined objects. Their role is to support research questions whose objects cannot be represented adequately as independent rows of attributes. The objective is to specify the relation type, direction, temporality, multiplicity, higher-order structure, evidence source, and uncertainty associated with each relational observation. The method begins from the substantive relation and builds a data structure capable of preserving its relevant properties.

Relational data can arise from direct observation, communication records, contracts, transactions, citations, organizational membership, co-presence, ownership, supply chains, trust elicitation, institutional authority, or computationally inferred connection. These sources do not automatically represent the same kind of relation. Communication can indicate coordination, conflict, obligation, or routine administration. Co-occurrence can represent joint participation without implying interpersonal connection. A relational dataset should therefore retain the semantics of the edge or higher-order object instead of reducing every relation to generic adjacency.

Definition 9.72 (Relational-data schema). A *relational-data schema* specifies the node or object types, relation or higher-order types, directionality, multiplicity, temporal indexing, weights or attributes, evidence source, observation rule, and uncertainty attached to relational observations.

Dyadic data can be insufficient where the empirical relation is collective. Teams, coalitions, joint contracts, multi-party obligations, shared institutional memberships, and process complexes can require hyperedges, simplices, faces, or other higher-order structures. Project design should therefore decide whether pairwise projection preserves the distinctions relevant to the claim. Where it does not, the data architecture should retain the higher-order object even if some analytical methods later use

pairwise approximations.

Relational missingness also differs from ordinary missing attributes. A missing edge can mean a relation did not exist, was not observed, was outside the sampled boundary, or was generated through a channel absent from the recording system. Boundary specification is therefore inseparable from network interpretation. Apparent centrality or isolation can change substantially when unobserved external ties are included.

The trajectory-complex framework can integrate relational data with event order. Events can anchor the formation, transformation, or dissolution of relations; edges can record specified local couplings; faces can record higher-order coordination; and provenance annotations can distinguish observed from inferred structure. Relational data thereby become historically embedded rather than frozen snapshots.

9.6.6 Longitudinal Data

Longitudinal data record repeated observations or reconstructable changes across time. Their role is to support inquiry into trajectories, persistence, delay, sequence, transition, feedback, institutional evolution, and changing option structures. The objective is to align observation intervals and historical coverage with the temporal scales of the generative process while preserving changes in measurement, membership, categories, and recording systems. The method combines temporal design, repeated measurement, event history, and historical metadata.

A longitudinal architecture should distinguish panel continuity from object continuity. The same identifier can refer to an organization whose internal structure has changed substantially. Different identifiers can refer to legal successors that inherit relevant functions. Individuals can enter and leave observation. Institutional categories can be redefined. Repeated measurement therefore requires an identity rule suited to the research question rather than an assumption that stable identifiers guarantee stable objects.

Definition 9.73 (Longitudinal-data continuity profile). *A longitudinal-data continuity profile records the observed units, identity criteria, observation intervals, entry and exit rules, measurement continuity, category changes, missing intervals, event-time anchors, and transformations required to compare observations across the chosen temporal horizon.*

Temporal resolution should correspond to plausible process speed. Annual observations can miss rapid feedback; daily data can produce enormous detail while remaining uninformative about institutional change that unfolds over years. Multiple resolutions may be necessary when fast and slow processes interact. The multiscale methods developed in Chapter 8 provide an analytical framework for these cases, while the data architecture specifies whether the required temporal information actually exists.

Longitudinal data can contain delayed observation. A capability can change before it is measured, a legal reform can be recorded before implementation, and an institutional problem can become visible only when a reporting threshold is crossed. Timestamp fields should therefore be interpreted according to what they date: occur-

rence, recording, publication, transaction settlement, measurement, or later archival registration.

Repeated observations also enable version-aware analysis. A project can preserve how values, classifications, or interpretations were known at each historical moment rather than backfilling later corrections into earlier states. This can matter when actors acted on contemporaneous information that was later revised.

9.6.7 Computational Data

Computational data are generated, transformed, inferred, simulated, embedded, classified, or otherwise produced through computational procedures. Their role is to extend analysis beyond directly collected or inherited observations while making algorithmic transformation itself part of the data-generating architecture. The objective is to distinguish source data from derived data, simulated data from empirical data, deterministic transformations from stochastic procedures, and computational convenience from evidential warrant. The method combines executable provenance, version control, parameter recording, and validation against the relevant target object.

Computational data can include cleaned tables, linked entities, geocoded records, embeddings, network projections, imputed values, model predictions, simulation trajectories, synthetic controls, automatically coded text, generated labels, and outputs from AI-assisted analysis. These objects can be essential to research while possessing different evidential statuses. A simulation trajectory demonstrates behavior of the encoded model under specified conditions. It does not become an empirical historical observation because it resembles one. A machine-generated classification can organize a large corpus while retaining error and category assumptions inherited from its training or prompt design.

Definition 9.74 (Computational-data lineage). A *computational-data lineage* records the source inputs, code or transformation procedure, software and model versions, parameter or prompt settings, stochastic seeds where relevant, intermediate artifacts, validation steps, and output object produced by a computational transformation.

Computational lineage should support reconstruction of material transformations, not merely final scripts. External services, model updates, inaccessible APIs, proprietary software, and changing dependencies can prevent exact reruns. Where perfect reproducibility is unavailable, the architecture can preserve enough information to support audit, approximate reconstruction, comparison, and future reinterpretation.

AI-assisted transformations require particular care because natural-language prompts, model versions, context windows, tool access, and stochastic generation can affect outputs. Derived classifications or summaries should remain linked to the source material and, where analytically consequential, to the instructions and review process through which they were accepted or revised. Human review does not erase computational provenance; it becomes another step in the lineage.

Computational data can also feed back into collection. Model outputs can identify cases for follow-up, simulation can reveal discriminating observations, and anomaly detection can direct archival search. Such adaptive workflows should record when

computational outputs changed later data acquisition so that the project history remains auditable.

9.6.8 Data Provenance

Data provenance records how a research datum or derived object came to exist in its present form. Its role is to make source, production, transformation, linkage, interpretation, and responsibility recoverable across the project. The objective is to connect every analytically consequential data object to the materials and operations from which it was derived, while preserving uncertainty and version history. The method is documentary and infrastructural: provenance is designed into the workflow rather than reconstructed only after publication.

Provenance can be represented at several granularities. A project-level record can identify datasets and their sources. A variable-level record can identify coding or transformation rules. A row- or edge-level record can link an observation to a specific source document, interview, event, or administrative record. A claim-level record can identify which data objects support a proposition. The appropriate granularity depends on the cost of recording and the likelihood that later interpretation will require return to the source.

Definition 9.75 (Data-provenance record). *A data-provenance record links a research data object to its source or production event, acquisition conditions, transformation steps, responsible agents or systems, version history, evidential interpretation, and known uncertainty at a granularity appropriate to the research claim.*

Provenance is particularly important when heterogeneous sources are merged. A single analysis table can contain primary observations, inherited administrative variables, archival codings, inferred network edges, and simulated values. If the merge removes source identity, later users can mistakenly treat all cells as having the same evidential status. Provenance-aware integration permits a common analytical representation while preserving origin.

The partially ordered trajectory complex can itself carry provenance annotations. Vertices, edges, and faces can be linked to the observations, documents, inferences, or simulations that support them. Competing historical reconstructions can share observed cells while differing in inferred extensions. This architecture allows uncertainty and alternative histories to remain localized.

Proposition 9.76 (Provenance-preserving integration). *Data integration strengthens cumulative generative inquiry when common analytical structures preserve recoverable links to source-specific provenance, transformation history, and evidential status.*

Provenance also supports accountability. Errors can be traced, corrections can propagate through dependent outputs, and disputed interpretations can return to the source material. This function becomes increasingly important when research workflows contain automated transformations or large numbers of intermediate computational artifacts.

9.6.9 Data Preservation

Data preservation concerns the continued intelligibility, accessibility, integrity, and lawful or ethical stewardship of research materials after immediate analysis. Its role is to support revision, replication, reinterpretation, cumulative research, and responsible closure. The objective is to preserve enough of the architecture to recover what existed, how it was generated and transformed, and which restrictions govern reuse. The method combines versioning, durable formats, metadata, access control, integrity checks, retention policy, and planned migration.

Preservation does not imply unrestricted release. Sensitive interviews, confidential administrative data, proprietary materials, restricted archives, or potentially harmful disclosures can require controlled access, anonymized derivatives, or metadata-only preservation. The architecture should distinguish preservation from publication and document each access condition.

Definition 9.77 (Research-data preservation package). *A research-data preservation package is a versioned collection of source or reference data where retention is permitted, metadata, provenance records, transformation code or specifications, schemas, documentation, integrity information, access conditions, and migration instructions sufficient to preserve the interpretability of the project's data architecture over time.*

Intermediate representations should be retained when they are difficult to regenerate or materially affected inference. Raw files and final outputs alone can leave consequential transformations opaque, while preserving every temporary cache adds unnecessary complexity. The selection principle is analytical significance: retain what is needed to reconstruct transformations, validate claims, and revisit decisions.

Format choice also matters. Open, documented formats can reduce software dependence, while originals should be retained when conversion loses information. Integrity records can identify accidental change, version control can distinguish correction from historical state, and persistent identifiers can stabilize citation where appropriate. These practices support the revisability emphasized throughout Part III.

Preservation is also temporal governance. Retention periods can depend on consent, institutional policy, law, cost, and future research value. Some data should eventually be destroyed, while historically unrecoverable materials can warrant long-term preservation. The choice should be explicit rather than accidental.

Proposition 9.78 (Preservation for revisability). *A research-data preservation strategy supports cumulative inquiry when it retains the data, metadata, provenance, transformations, access conditions, and version history required to revisit consequential analytical decisions while respecting the ethical and institutional conditions that govern retention and reuse.*

Data architecture connects empirical access with long-term research responsibility. Its heterogeneous production pathways remain recoverable through provenance and preservation, providing the basis for the representation architecture developed next.

9.7 Representation Architecture

This section develops representation architecture as the design layer through which research objects, data structures, and methodological operations are given analyzable form. Its role in Chapter 9 is to follow the data architecture of Section 9.6 with an explicit account of how evidence-bearing materials are transformed into narratives, tables, graphs, geometries, fields, algebraic structures, dynamical models, and spacetime representations. The objective is to make representation choice auditable by stating what each representation preserves, what operations it permits, which distinctions it suppresses, and how several representations can be coordinated without being treated as interchangeable. The discussion proceeds through narrative, tabular, graph, geometric, field, algebraic, dynamical, and spacetime representations, followed by multiple-representation design and representation loss. The method is comparative and architectural: representations are evaluated relative to the research object and inferential task rather than ranked by apparent formal sophistication.

Representation is an interface between theory, data, method, and inference. A theoretical concept such as institutional capacity, relational dependence, generative accessibility, or option space cannot enter analysis directly. It is represented through selected objects, attributes, relations, temporal structures, categories, metrics, fields, transition rules, or other formal and semi-formal devices. The representation makes some differences visible and actionable while leaving others outside the immediate analytical frame. A research design therefore requires more than choosing a convenient format. It requires a defensible relation between the represented object and the distinctions on which the eventual claim depends.

The same empirical process can admit several representations. An institutional reform can be narrated as a historical sequence, tabulated as dated changes in formal rules, represented as a graph of authority relations, embedded geometrically in a state space, expressed as a field of distributed enforcement intensity, represented algebraically through admissible operations, modeled dynamically through state transitions, or reconstructed as a partially ordered spacetime of events and accessibility. These representations can illuminate different aspects of the same process. Their plurality does not imply that they are equivalent, and their differences can be analytically productive.

A representation can be expressed abstractly as a map from a research object into a structured analytical space. The generic form is stated in Equation 9.1.

$$\rho : \mathcal{O} \longrightarrow \mathcal{R}, \quad o \longmapsto \rho(o), \quad (9.1)$$

where $\mathcal{O}$ denotes the research objects admitted by the design and $\mathcal{R}$ denotes the representational space. Equation 9.1 is intentionally general. The map can encode narrative ordering, tabular attributes, graph relations, coordinates, fields, algebraic operations, dynamical states, or spacetime structure. Its methodological value lies in making the translation explicit enough that the analyst can state which properties of o are preserved, transformed, aggregated, or omitted in $\rho(o)$.

Definition 9.79 (Representation-architecture contract). A *representation contract* specifies the research object represented, the representational form, the preserved

distinctions, admissible analytical operations, evidential inputs, scale and temporal resolution, known transformation assumptions, and principal forms of representation loss relevant to the intended claim.

Definition 9.79 provides the common design discipline for the ten subsections below. The contract can remain brief for a simple representation and become more detailed for a formal model. Its purpose is to prevent analytical convenience from silently becoming ontological commitment or inferential overreach.

9.7.1 Narrative Representation

Narrative representation organizes events, actors, interpretations, relations, and transformations into a temporally and conceptually coherent account. Its role in integrated design is to preserve sequence, context, meaning, contingency, and interpretive connection when these features cannot be adequately reduced to independent variables or static structures. The objective is to make narrative construction sufficiently explicit that chronology, interpretation, evidential provenance, and causal or generative suggestion remain distinguishable. The method combines historical reconstruction, interpretive analysis, process tracing, and explicit source annotation.

Narrative representation is especially useful when the research object contains heterogeneous events whose significance depends on order and context. A policy decision, organizational response, reinterpretation of a rule, change in trust, technical failure, and later institutional reform can form one generative history while belonging to different data types. Narrative permits these differences to remain visible and can preserve how actors understood changing conditions at each point in the process.

A narrative nevertheless contains substantial representational choices. The analyst selects a beginning and end, determines which events deserve inclusion, assigns relative prominence, identifies transitions, and decides how much continuity to infer between surviving traces. These choices can alter the apparent mechanism. A compressed narrative can make change appear abrupt; a more finely resolved account can reveal gradual preparation. A retrospective narrative can make a realized path appear inevitable even when several alternatives were plausible at the time.

Definition 9.80 (Narrative-representation profile). *A narrative-representation profile records the temporal boundary, principal actors and objects, event-selection rule, evidential sources, sequence structure, interpretive links, uncertainty, alternative plausible sequences, and narrative compressions through which a historical or generative process is represented.*

Narrative representation can coexist with partial order. Exact dates are unnecessary when evidence only supports precedence or overlap. A narrative can state that two processes developed concurrently, that one event occurred before another within an interval, or that ordering remains uncertain. This makes narrative compatible with the partially ordered event architecture developed in Chapter 8 rather than forcing every historical account into a total chronology.

The principal design risk is narrative closure. Coherent prose can conceal weak inferential bridges because grammatical continuity makes transitions feel natural. A

representation contract should therefore identify which links are observed, which are interpretive, which are supported by mechanism evidence, and which remain conjectural. Narrative strength lies in contextual integration; its adequacy increases when coherence remains distinguishable from evidential certainty.

9.7.2 Tabular Representation

Tabular representation organizes observations into rows, columns, indices, keys, and comparable fields. Its role is to support systematic comparison, measurement, filtering, aggregation, statistical analysis, and linkage across observations. The objective is to specify what constitutes a row, what each column means, how missingness and repeated observations are encoded, and which relations are lost when heterogeneous objects are flattened into a table. The method combines schema design, measurement discipline, versioning, and provenance-aware transformation.

Tables are powerful because they make many analytical operations simple and transparent. A case-by-variable table can support comparison across cases. A person-period table can represent repeated observations. An event table can retain timestamps, types, and provenance. A relation table can store source and target identifiers together with relation type and time. Several linked tables can preserve more structure than one wide table while remaining compatible with conventional analytical software.

The tabular form also encourages assumptions that should remain explicit. Rows can imply independence even when observations are relationally coupled. Columns can imply stable measurement even when categories change historically. A rectangular matrix can conceal higher-order relations, nested institutions, or branching trajectories. Missing cells can be interpreted as absent values despite representing non-observation, non-applicability, structural absence, or censored access.

Proposition 9.81 (Schema-relative comparability). *Tabular comparison is methodologically strongest when row identity, column semantics, temporal alignment, missingness, and category continuity are specified before analytical operations treat entries as directly comparable.*

Proposition 9.81 links representation architecture to the data architecture developed in Section 9.6. A well-designed table can preserve source identifiers, versions, event times, uncertainty flags, and provenance. A poorly designed table can erase these distinctions during cleaning. Tabular representation should therefore be treated as an analytical transformation whose losses are documented rather than as a neutral container.

Multiple tables can sometimes provide a better representation than one flattened dataset. Separate event, actor, relation, institution, and measurement tables can be linked through stable identifiers. This architecture can preserve one-to-many and many-to-many relations while permitting statistical extraction for particular analyses. The research design should record which extraction or aggregation created the analytical table used for a specific claim.

9.7.3 Graph Representation

Graph representation expresses objects through nodes, relations through edges, and, where required, higher-order structures through hyperedges, simplices, faces, or typed relational objects. Its role is to make topology, connectivity, path structure, centrality, clustering, brokerage, dependence, and relational accessibility analytically visible. The objective is to align graph structure with the substantive relation being studied and to preserve direction, type, multiplicity, temporality, higher-order composition, and boundary conditions where those distinctions affect inference. The method begins with relational semantics and only then selects graph-theoretic operations.

A graph can represent communication, authority, exchange, ownership, citation, trust, supply, legal obligation, technical compatibility, or another relation. These meanings are not interchangeable. An edge therefore requires a relation contract specifying what is connected, how the relation is observed, whether it is directed or reciprocal, whether it persists between observations, and what an absent edge means.

Graph representation can reveal structure that tabular attributes obscure. Two actors with identical individual characteristics can occupy very different network positions. A local intervention can have different consequences depending on redundancy, brokerage, clustering, or exposure to multiple paths. Diffusion, coordination, and vulnerability can depend on topology rather than on independent actor attributes.

The graph form can also compress excessively. A binary edge can hide changing intensity, content, or institutional meaning. Pairwise projection can distort a collective relation. Snapshot graphs can erase the sequence through which ties formed. A graph that includes only observed participants can create artificial centrality by omitting external relations. The representation architecture should therefore state whether the graph is static, temporal, multiplex, higher-order, weighted, probabilistic, or embedded in a broader event history.

Definition 9.82 (Graph-representation contract). A *graph-representation contract* specifies node types, relation types, directionality, multiplicity, temporal indexing, weights or attributes, higher-order structures, boundary rules, evidence supporting nodes and relations, and the analytical operations for which the graph is intended.

The trajectory-complex framework offers a bridge between graph and historical representation. Graph edges can describe relational structure while event vertices and partial order preserve when relations formed, changed, or dissolved. This separation is useful because relational adjacency and temporal precedence answer different questions even when both appear in one visual diagram.

9.7.4 Geometric Representation

Geometric representation maps objects or configurations into spaces with notions of position, distance, neighborhood, boundary, continuity, basin structure, deformation, or curvature. Its role is to make proximity and spatial organization analytically tractable when the research question depends on how configurations are arranged

relative to one another. The objective is to specify the coordinate construction, metric or neighborhood rule, dimensionality, topology, and interpretation of geometric properties. The method treats geometry as a representation of analytically defined differences rather than as an automatic ontology of the target domain.

A geometric representation can place organizations in a capability space, policies in a multidimensional institutional space, households in an accessibility landscape, or trajectories within a state space. Distances can represent dissimilarity, transition cost, institutional separation, or another substantively defined relation. Neighborhoods can identify configurations reachable through small changes. Basins can represent regions from which trajectories tend toward similar regimes under a specified dynamical model.

The empirical meaning of geometry depends on construction. Euclidean distance can be inappropriate when dimensions have different units or when transition costs are directional. Dimensional reduction can preserve some local relations while distorting global structure. An embedding can create visually convincing clusters even when distances outside the optimization objective are poorly preserved. A coordinate system can also make continuous what the underlying object treats categorically.

Proposition 9.83 (Geometric-meaning requirement). *A geometric representation supports substantive inference when coordinates, distance or neighborhood structure, and geometric transformations have interpretations that are warranted by the research object and the intended analytical operation.*

Geometric representations can be especially useful in multiple-representation designs. A network can be embedded geometrically to study neighborhood structure, while the original graph remains available to preserve exact ties. A dynamical system can evolve within a geometric state space, while narrative evidence explains how the coordinates correspond to historically meaningful categories. Such combinations should retain the translation between representations rather than replacing one representation with another silently.

9.7.5 Field Representation

Field representation assigns a value or structured state to positions in a domain and represents how distributed conditions vary and interact across that domain. Its role is to support inquiry where influence, constraint, capability, expectation, value, or institutional effect is distributed rather than localized in isolated objects. The objective is to specify the carrier domain, field variables, interaction structure, temporal indexing, boundary conditions, and evidence linking the field to the target process. The method is appropriate when spatial or relational distribution is itself consequential to generation.

A field can be defined over physical space, network-derived coordinates, institutional positions, a continuous approximation to a relational system, or another structured domain. One field might represent accessibility, another enforcement intensity, and another trust or informational density. Several fields can interact, but their values need not share units or ontological status.

Field representation can reveal gradients, interfaces, local concentrations, dis-

tributed influence, and boundary effects. It can show why the same intervention produces different outcomes at different positions or why local changes propagate unevenly. It can also support formal models of coupled evolution when the evidence and measurement architecture justify such structure.

The principal risk is smoothing away discrete relations and institutional discontinuities. A continuous field approximation can make a sharp legal boundary appear gradual. Interpolation can fill regions with values unsupported by observation. Kernel methods can create apparent influence across distances that lack a substantive transmission mechanism. Field construction should therefore document the domain, interpolation or estimation method, boundary conditions, and scale at which the continuous approximation remains meaningful.

Definition 9.84 (Field-representation profile). *A field-representation profile specifies the carrier domain, field variables, units or value types, interaction and boundary rules, temporal resolution, estimation or interpolation procedure, evidential support, and scale over which the field representation is intended to remain valid.*

Field and graph representations can complement one another. A network can preserve discrete relations while a field approximates distributed conditions across positions generated from that network. The design should keep the mapping explicit so that conclusions derived from the field are not silently attributed to exact relational structure.

9.7.6 Algebraic Representation

Algebraic representation expresses objects through admissible operations, compositions, equivalence relations, invariants, and transformation structures. Its role is to clarify how relations or processes combine and which properties remain stable under specified operations. The objective is to identify the typed objects and operations for which algebraic structure is substantively meaningful while avoiding stronger axioms that the target process does not support. The method begins from compositional requirements and introduces algebraic structure only to the extent required by the research question.

Algebraic representation can be useful when a research problem concerns composition rather than magnitude. Institutional operations can be composed in different orders; transformations can commute or fail to commute; several pathways can belong to the same equivalence class under a chosen criterion; and invariants can identify structure preserved across transformations. These questions can be difficult to express through ordinary tabular data alone.

The representation can remain partial and typed. Some operations can be undefined for certain object pairs. A transformation can lack an inverse. Composition can depend on institutional compatibility or event order. These features matter because many historical and economic processes are irreversible, path-dependent, or conditionally composable. Imposing a group or ring structure merely because those objects are mathematically familiar can distort the target process.

Proposition 9.85 (Algebraic commitment discipline). *An algebraic representation gains methodological adequacy when each operation, identity, equivalence, or invari-*

ance claim is linked to an interpretable operation in the research design and stronger algebraic axioms are introduced only where their substantive meaning is defensible.

Algebraic representation can also coordinate other representations. A transformation can act on a graph, field, geometry, or state space. Category-theoretic mappings can organize translations among such representations. These uses make algebraic structure an architectural resource, but the evidential meaning remains determined by the objects and operations supplied by the research problem.

9.7.7 Dynamical Representation

Dynamical representation specifies how states or configurations change through time under an explicit transition rule. Its role is to make feedback, stability, path dependence, bifurcation, attractor structure, stochastic variation, and changing parameters analyzable within one temporal model. The objective is to define the state variables, transition structure, time scale, parameters, exogenous inputs, and relation between model trajectories and empirical histories. The method converts a static representation into an explicit account of temporal evolution.

A dynamical representation can be deterministic, stochastic, discrete, continuous, event-driven, or hybrid. Its state can contain individual attributes, relational structure, institutional rules, field values, capacities, constraints, or other quantities relevant to the mechanism. The transition rule determines how one state or configuration can generate another under specified conditions.

The main design question concerns closure. A model can treat some conditions as fixed parameters even when they change historically. This can be adequate for a narrow horizon and misleading for a longer one. A project that studies transformation of the generative rule can require a higher-level representation in which parameters, rules, or admissible operations themselves evolve. The representation contract should therefore identify which components are dynamic, which are fixed, and which transformations lie outside the model.

Definition 9.86 (Dynamical-representation contract). A *dynamical-representation contract* specifies state variables, transition rules, temporal resolution, parameters, stochastic components where relevant, boundary conditions, initialization, observables, and the evidential interpretation assigned to model trajectories.

Dynamical representation can support generative inference when the encoded transition structure corresponds to mechanism evidence and when model trajectories can be compared with observed or reconstructed histories. A successful fit alone remains insufficient to establish mechanism identity because several transition structures can produce similar trajectories. Multiple-model and robustness analysis later in Chapter 9 therefore remain necessary.

9.7.8 Spacetime Representation

Spacetime representation integrates event order, relational or geometric structure, temporal depth, and generative accessibility within one historical representation. Its role in integrated design is to support research problems in which a single timeline or fixed state space is inadequate because events can be only partially ordered, subsys-

tems can evolve on heterogeneous temporal schedules, and the accessibility of later configurations depends on sequence and relational structure. The objective is to specify events, ordering relations, couplings, higher-order process structures, boundary conditions, and admissible histories while preserving provenance and uncertainty. The method draws on the spacetime framework developed in Chapter 8 without requiring a physical spacetime ontology.

A spacetime representation is especially useful for complex historical processes. Several events can occur concurrently or with unresolved order. Institutional change can proceed slowly while local transactions occur rapidly. A later configuration can become accessible only after several partially independent conditions are satisfied. Alternative histories can share observed boundary states while differing in intermediate couplings or event order.

The partially ordered generative trajectory complex provides one representation of this structure. Vertices can anchor events, edges can represent specified local couplings, faces can represent higher-order process or relational structure, and a partial order can represent precedence without equating precedence with causation. Typing and provenance can distinguish observed, inferred, modeled, and counterfactual components.

Proposition 9.87 (Spacetime-representation adequacy). *A spacetime representation is most useful when the research question requires joint analysis of event order, historical accessibility, relational or geometric structure, and alternative admissible histories that would be distorted by a single total chronology or fixed state-space trajectory.*

Spacetime representation is therefore a relatively rich commitment. Simpler representations remain preferable when they preserve the distinctions needed for the claim. The design principle is adequacy rather than maximal formal richness.

9.7.9 Multiple Representations

Multiple-representation design coordinates several representations of one research object or process while preserving their distinct analytical roles. Its role is to support methodological pluralism within the architecture of a single project. The objective is to determine when representations are complementary, partially translatable, redundant, conflicting, or irreducible, and to document the mappings through which findings move from one representation to another. The method treats representation plurality as an explicit design choice rather than as an accidental accumulation of visualizations and models.

A project can use narrative representation to preserve historical meaning, a table for systematic comparison, a graph for relational topology, a geometric embedding for proximity, and a dynamical model for transition structure. These representations can share some underlying data while emphasizing different distinctions. Agreement among them can strengthen confidence in a representation-independent finding, while disagreement can reveal transformation loss, scale mismatch, or incompatible assumptions.

Translation among representations should be explicit. A graph converted into an adjacency matrix can preserve pairwise ties while losing visual embedding. A higher-

order complex projected into a graph can lose group-level structure. A narrative coded into an event table can gain systematic comparability while losing contextual nuance. A continuous field estimated from discrete observations can add interpolation assumptions. Each translation therefore creates a new analytical object with its own provenance.

Definition 9.88 (Multiple-representation architecture). A *multiple-representation architecture* specifies the set of representations used for a research object, the analytical function of each representation, the mappings among them, the distinctions preserved or transformed by each mapping, and the rules used to adjudicate agreements or divergences across representations.

Multiple representations can also be sequenced. Narrative and documentary analysis can define objects before graph construction. Graph results can identify structures for qualitative follow-up. Formal simulation can expose discriminating observations that reshape the empirical representation. Such recursion should remain documented so that later claims can be traced through the representational history of the project.

Representation plurality does not require every representation to carry equal evidential weight. One representation can be primary for a particular claim while another serves as a robustness check or heuristic. The architecture should state these roles rather than treating all outputs as interchangeable confirmations.

9.7.10 Representation Loss

Representation loss concerns the distinctions, uncertainty, context, scale relations, or historical structure that become unavailable or distorted when a research object is translated into a particular representation. Its role is to make the costs of analytical tractability visible and to connect representation architecture with the translation-loss principle developed in Section 9.3. The objective is to localize loss, determine whether it matters to the intended claim, and design complementary representations or sensitivity checks where consequential information has been removed. The method compares the source object, the representational transformation, and the inferential operations that depend on the result.

Loss can arise through aggregation, discretization, dimensional reduction, category stabilization, pairwise projection, temporal smoothing, spatial interpolation, coordinate choice, narrative compression, model closure, or selective visualization. Some losses are intentional. A representation becomes useful partly because it suppresses detail. The methodological question is whether the suppressed distinctions are irrelevant to the claim or whether their removal changes the inferential meaning of the result.

A representation-loss profile can be described through several dimensions: identity loss, relational loss, temporal loss, scale loss, contextual loss, uncertainty loss, and provenance loss. These dimensions need not be combined into one score. They provide a structured record of what becomes harder to recover after representation.

A compact formal expression for representation loss is stated in Equation 9.2.

$$\mathcal{L}_\rho = (L_{\text{id}}, L_{\text{rel}}, L_{\text{time}}, L_{\text{scale}}, L_{\text{context}}, L_{\text{uncert}}, L_{\text{prov}}), \quad (9.2)$$

where the components in Equation 9.2 record the analytically relevant losses associated with representation map ρ . The profile can remain qualitative or be operationalized more formally where the project supports such assessment.

Loss can sometimes be mitigated through provenance-preserving design. A reduced dataset can retain links to the full source. A graph can retain edge-level evidence and timestamps. A geometric embedding can be accompanied by stress or distortion diagnostics. A narrative can link statements to source passages. A simulated history can distinguish observed from generated components. These practices do not eliminate loss, but they keep important distinctions recoverable.

Proposition 9.89 (Representation-loss discipline). *A research representation supports stronger cumulative inference when analytically consequential losses are identified, localized, and connected to the claims that depend on the representation, with complementary representations or sensitivity analysis used where those losses could alter the conclusion.*

Representation architecture therefore joins analytical power with explicit reduction. Narrative, tabular, graph, geometric, field, algebraic, dynamical, and spacetime forms offer different interfaces to the research object. Multiple-representation design coordinates them, while representation-loss records keep the costs of translation visible. The resulting architecture provides the basis for constructing the method portfolio developed next.

9.8 Method Portfolio

This section develops the method portfolio as the project-level architecture through which several methodological traditions are assigned differentiated roles within one Generative Relational research design. Its role in Chapter 9 is to translate the representation architecture of Section 9.7 into an operational strategy for inquiry. The objective is to specify how a core method can carry the principal inferential burden while supporting, interpretive, quantitative, formal, historical, and computational methods contribute complementary forms of access, validation, translation, and revision. The discussion proceeds through these method roles and closes with methodological redundancy and methodological economy. The method of argument is architectural and comparative: methods are evaluated according to their function in the design, their evidential contribution, their interaction with other methods, and the costs introduced by coordination.

A method portfolio is useful because complex generative questions rarely map cleanly onto one methodological operation. A project may need historical reconstruction to establish sequence, interviews to recover meaning, quantitative analysis to assess distribution and temporal pattern, formal modeling to clarify mechanism implications, and simulation to explore admissible trajectories. These contributions are related, yet they are not interchangeable. A historical method can provide direct access to sequence while remaining weak for population prevalence. A quantitative method can estimate patterned variation while leaving mechanism interpretation open. A formal model can expose logical consequences while depending on empirical work for correspondence with the target domain.

The method portfolio therefore assigns roles before it accumulates techniques. One method can be central because it addresses the project's principal inferential bottleneck. Other methods can support identification of objects, translation between representations, measurement, interpretation, mechanism discrimination, sensitivity analysis, or robustness assessment. The portfolio can change as the research question evolves. A project that begins with exploratory historical inquiry can later adopt a quantitative core when sufficient measurement becomes available, or a formal model can move from a supporting role to a core role when the project turns toward mechanism comparison.

Definition 9.90 (Method portfolio). A *method portfolio* is a documented configuration of research methods in which each method has an explicit analytical role, evidential function, relation to the research question and representation architecture, interfaces with other methods, and conditions under which its role may be revised.

Definition 9.90 treats methodological plurality as designed coordination rather than accumulation. The portfolio should identify what each method is expected to contribute, what kinds of claims it can support, what inputs it requires, and what remains outside its scope. This functional decomposition also creates a basis for sequencing methods in Section 247.

9.8.1 Core Method

The core method carries the principal inferential burden of a research project. Its role is to provide the primary route from evidence to the central claim while remaining coordinated with the theoretical, representational, and evidential architecture established earlier in Chapter 9. The objective is to identify which inferential problem is most central to the research question and to select a method whose strengths correspond to that problem. The method can be historical, interpretive, quantitative, formal, computational, intervention-based, or another defensible approach; core status is a design role rather than a disciplinary hierarchy.

Core-method selection begins from the research question rather than from researcher familiarity. A project concerned with how an institution emerged through a sequence of contingent events may require historical reconstruction as its core method. A project centered on heterogeneous treatment effects can place a quantitative causal design at the core. A project whose main question concerns whether a candidate mechanism can generate several observed regimes can place formal or computational modeling at the center, provided the model's correspondence with the empirical object is independently supported.

The core method should also correspond to the project's strongest evidential source. A process-tracing design becomes fragile when the relevant intermediate states are poorly documented. A longitudinal quantitative design becomes fragile when measurement categories change unpredictably across time. A formal dynamical model becomes difficult to interpret when the state variables and transition assumptions lack empirical meaning. Selecting a core method therefore requires joint consideration of the question, object, representation, data architecture, and evidential access.

Definition 9.91 (Core-method contract). A *core-method contract* specifies the pri-

mary inferential task assigned to the core method, the evidence and representations it requires, the claims it is expected to support, the principal assumptions under which those claims remain warranted, and the complementary functions delegated to supporting methods.

The contract makes the project's center of gravity explicit. It also limits methodological overreach. A quantitative core does not automatically absorb historical interpretation; a historical core does not automatically establish causal magnitude; a formal core does not automatically identify its own empirical parameters. Supporting methods remain necessary where the core method reaches its evidential boundary.

Core status can change during inquiry. A project can discover that its initial method cannot address the revised research question or that unexpected evidence reveals another inferential bottleneck. Such changes should be recorded as design revisions. Methodological flexibility is compatible with rigor when the reason for the change, the consequences for earlier results, and the revised division of labor remain visible.

Proposition 9.92 (Core-method alignment). *A core method gains project-level adequacy when its inferential strengths address the principal research question, its required evidence is available at sufficient quality, and its known blind spots are assigned to explicit supporting methods or retained as limitations.*

9.8.2 Supporting Methods

Supporting methods provide analytical functions that the core method does not perform adequately on its own. Their role is to strengthen object construction, interpretation, measurement, mechanism identification, comparison, robustness assessment, or translation across representations without obscuring which method carries which inference. The objective is to construct a portfolio in which each supporting method fills a specified gap or tests a specified vulnerability. The design therefore distinguishes complementary support from ornamental methodological variety.

A supporting method can operate before, alongside, or after the core method. Qualitative interviews can precede quantitative measurement by clarifying categories and mechanisms. Network analysis can run alongside historical reconstruction by locating relational structures for documentary follow-up. Formal modeling can follow process tracing by testing whether the reconstructed mechanism can generate the observed trajectory under explicit assumptions. Sensitivity analysis can follow several methods by determining whether conclusions depend on one representation or parameter choice.

Support can also concern translation between data types. Documentary evidence can explain the administrative meaning of variables inherited from a secondary dataset. Archival work can identify a historical discontinuity that requires splitting a longitudinal series. A geometric representation can expose neighborhood structure in a high-dimensional dataset and then direct qualitative examination toward cases near a boundary. These uses make supporting methods part of the inferential architecture rather than independent side analyses.

Definition 9.93 (Supporting-method role). *A supporting-method role specifies the inferential gap, representational translation, validation task, sensitivity check, or*

complementary evidence function for which a secondary method is included in the project.

Supporting methods should have stopping conditions. If a method is included only because it is available or fashionable, it can increase coordination cost without increasing evidential value. A supporting method is justified when the project can state which uncertainty, assumption, translation, or inferential boundary it addresses.

Support can remain asymmetric. One method can supply categories that another estimates quantitatively; the quantitative result need not reciprocally validate the original category. One method can test a mechanism implication without reproducing the historical evidence that motivated it. Explicit asymmetry prevents methodological plurality from being mistaken for mutual confirmation.

9.8.3 Interpretive Methods

Interpretive methods provide access to meaning, classification, situated understanding, symbolic structure, and actors' or institutions' practical interpretations of events. Their role in a method portfolio is to reconstruct the semantic conditions through which actions, relations, rules, and categories become intelligible and consequential. The objective is to identify where generative processes depend on meaning and to determine which parts of that meaning can be translated into other representations without erasing their historical or contextual structure. The method portfolio can assign interpretive inquiry a core or supporting role depending on the research question.

Interpretive methods are especially important when formal categories and lived or enacted meanings diverge. A legal rule can have one textual form and several practical interpretations. A statistical category can aggregate actors who understand their position differently. A policy can generate different responses because the same signal is interpreted through different institutional histories. A network tie can encode interaction while leaving the meaning of the relation open. Interpretive inquiry can therefore supply the semantic structure required to avoid misreading formal or quantitative representations.

Interpretive evidence can include interviews, discourse, institutional language, legal reasoning, ethnographic observation, correspondence, classificatory practice, and symbolic artifacts. Its contribution depends on the relation between the evidence and the interpretive claim. A frequently repeated term does not by itself establish the practical meaning assigned to it; a participant account can illuminate one position without representing the entire field. Interpretive methods therefore require explicit case, field, and provenance architecture like other methods.

Proposition 9.94 (Interpretive portfolio function). *Interpretive methods strengthen a method portfolio when the research claim depends on meaning, classification, recognition, practical understanding, or symbolic mediation that would be materially distorted by treating recorded behavior or formal category labels as self-interpreting.*

Interpretive methods can also challenge the representation architecture itself. A category used in quantitative analysis may prove historically unstable. A formal distinction may have little correspondence with institutional practice. A graph edge may

combine several relation types that actors experience differently. Such findings can trigger revision of the data, representation, or theory rather than remaining confined to an interpretive appendix.

9.8.4 Quantitative Methods

Quantitative methods provide systematic analysis of magnitude, distribution, association, temporal pattern, uncertainty, and defined contrasts across measured observations. Their role in a method portfolio is to make patterned variation comparable at scales or frequencies that other methods may not address efficiently. The objective is to connect measurement architecture to an inferential task while preserving the historical and institutional conditions under which variables acquire meaning. Quantitative analysis can serve as a core method or as a supporting method for prevalence, comparison, estimation, or robustness.

The portfolio should identify what the numbers represent before selecting an estimator. Variables inherit definitions from data-production systems. Missingness can be generated by institutional access. Time series can contain classification changes. Relational measures can depend on observation boundaries. Quantitative analysis therefore remains connected to Sections 9.6 and 9.7: numerical tractability does not remove provenance or representation loss.

Quantitative methods can contribute several distinct functions. Descriptive statistics can map distributions and heterogeneity. Longitudinal models can characterize temporal persistence and divergence. Causal designs can estimate defined contrasts under explicit assumptions. Network statistics can quantify topology. Sensitivity analysis can assess parameter, boundary, or model dependence. These functions should remain differentiated because one quantitative result does not automatically support all of them.

Definition 9.95 (Quantitative-method role). A *quantitative-method role* specifies the measured objects, estimand or target quantity, comparison structure, uncertainty representation, assumptions, temporal and population scope, and relation between the numerical result and the broader generative claim.

The result can remain evidentially important even when it does not carry the central attribution. A stable association can constrain mechanism models. A distributional estimate can show that a qualitative case is unusual. A null average effect can conceal divergent trajectories that invite subgroup or relational analysis. Quantitative methods are therefore valuable within a portfolio partly because they can expose where another method's local account does or does not generalize.

9.8.5 Formal Methods

Formal methods provide explicit representations of objects, relations, transformations, dynamics, composition, geometry, probability, and admissible histories. Their role in a method portfolio is to clarify assumptions, derive implications, compare mechanism structures, identify invariants, expose non-identifiability, and support disciplined counterfactual or dynamical reasoning. The objective is to assign formalism a specific analytical task and to keep the bridge between the formal object and the

empirical target visible. Formal methods can be core when the research question is itself structural or mechanism-theoretic, and supporting when they organize or test claims produced through other methods.

The formal-method family developed in Chapter 8 includes dynamical, stochastic, field-theoretic, algebraic, group-theoretic, category-theoretic, geometric, and space-time representations. These formalisms make different distinctions available. A dynamical model foregrounds transition structure. A category-theoretic representation foregrounds typed composition and translation. A geometric representation foregrounds distance, neighborhood, and basin structure. A partially ordered trajectory complex preserves event order, coupling, higher-order composition, and alternative admissible histories.

Formal methods can sharpen research even before parameter estimation. A mechanism stated verbally may contain hidden ambiguity about order, feedback, or scale. Formalization can show that two mechanisms are observationally equivalent under current evidence or that a proposed explanation requires an unmeasured intermediate state. Such findings can redirect data collection and supporting methods.

Proposition 9.96 (Formal-method correspondence). *A formal method contributes to a method portfolio when its objects and operations correspond to interpretable features of the research problem, its assumptions are inspectable, and its derived implications create empirical or conceptual leverage that would be difficult to obtain through prose description alone.*

Formal richness also has costs. Stronger structure can introduce assumptions that the target domain does not justify. A smooth manifold can erase discontinuity; a total order can erase concurrency; a fixed transition rule can erase institutional transformation. The portfolio should therefore prefer the weakest formal commitment that performs the required analytical task.

9.8.6 Historical Methods

Historical methods reconstruct sequence, formation, contingency, persistence, category change, and the layered accumulation of institutions or relations through time. Their role in a method portfolio is to preserve the historical generation of the research object and to prevent current categories or structures from being projected backward as timeless conditions. The objective is to identify the temporal architecture within which later evidence and mechanisms acquire meaning. Historical methods can serve as a core approach in process-centered research and as a supporting architecture for quantitative, formal, or computational methods that depend on historically stable definitions.

Historical inquiry can establish antecedent conditions, turning points, critical junctures, institutional layering, path dependence, and changes in the recording system itself. It can reveal that an apparent variable did not exist in the same form throughout the period under study. It can identify abandoned alternatives that make a later institutional path appear less inevitable. It can also provide the event-order constraints needed for process tracing or the initialization required for historical simulation.

The method portfolio should distinguish documentary availability from historical

relevance. Surviving records are selective, and institutional archives often preserve some actors or processes more effectively than others. Historical methods therefore benefit from the data-provenance and archival-access profiles developed in Section 9.6. Missing records can remain a research limitation rather than being converted into evidence of non-occurrence.

Definition 9.97 (Historical-method role). A *historical-method role* specifies the periodization, event and process boundaries, source architecture, continuity criteria, category histories, and inferential function through which historical reconstruction contributes to the project.

Historical methods can also challenge formal closure. A mechanism estimated within one period may cease to operate after institutional reform. A state-space variable can change meaning. A network boundary can shift. A rule treated as exogenous can itself have a history. These findings can motivate model segmentation, parameter variation, or revision of the generative rule.

9.8.7 Computational Methods

Computational methods provide executable procedures for transformation, simulation, search, estimation, visualization, large-scale comparison, and exploration of explicit generative rules. Their role in a method portfolio is to extend analytical reach where complexity, dimensionality, stochasticity, or combinatorial structure makes manual reasoning insufficient. The objective is to distinguish computational implementation from evidential warrant and to preserve the provenance of computationally generated outputs. Computational methods can implement quantitative or formal models, support exploratory analysis, or become a core simulation method when the research question concerns emergent trajectories.

Computational work can include agent-based modeling, network simulation, historical simulation, stochastic path generation, numerical integration, optimization, machine-assisted coding, and large-scale data transformation. These activities differ in evidential role. Numerical integration evaluates a specified formal model; agent-based simulation generates trajectories under encoded local rules; automated coding transforms evidence into a representation; optimization searches a defined objective landscape. Treating all computational outputs as one evidential category would obscure these differences.

The data architecture should preserve source data, transformation scripts, software environments, parameter settings, random seeds where relevant, and generated artifacts. Computational provenance matters because two visually identical outputs can arise from different preprocessing or model assumptions. Reproducibility also supports later reinterpretation when algorithms, categories, or software environments change.

Proposition 9.98 (Computational role transparency). *Computational methods contribute more clearly to a method portfolio when each computational stage is classified by its role in transformation, estimation, simulation, exploration, visualization, or inference and when generated outputs remain distinguishable from empirical observations.*

AI-assisted computational work requires the same distinction. Generated code,

classifications, model suggestions, or synthetic trajectories can increase exploratory capacity while requiring independent validation where they enter an evidential claim. The methodological portfolio should record which operations were machine-assisted and where human or external validation entered the workflow.

9.8.8 Methodological Redundancy

Methodological redundancy concerns deliberate overlap among methods that permits one inference, object, or pattern to be examined through more than one analytical route. Its role is to increase diagnostic power where methods have partially independent assumptions or blind spots. The objective is to distinguish productive redundancy from simple duplication and to determine when disagreement among methods should trigger revision rather than averaging. The method portfolio treats redundancy as a targeted robustness design.

Redundancy is productive when the methods fail differently. Interviews and administrative records can both address institutional practice while carrying different observation biases. A historical reconstruction and a dynamical model can both address trajectory structure while relying on different assumptions. A graph representation and qualitative relational analysis can both address network organization while preserving different aspects of relational meaning. Agreement across such methods can constrain alternative explanations more strongly than repeated use of nearly identical measurements.

Redundancy provides limited value when several methods reproduce the same assumption or data transformation. Two statistical models fitted to the same variables can appear methodologically plural while sharing the same category instability and missingness. Several simulations can differ in software implementation while encoding the same mechanism structure. The portfolio should therefore assess independence of failure modes rather than count the number of techniques.

Definition 9.99 (Productive methodological redundancy). *Productive methodological redundancy* is intentional overlap among methods whose partly distinct assumptions, evidence channels, or representational blind spots create additional capacity to detect error, discriminate mechanisms, assess robustness, or reveal unresolved disagreement.

Redundancy can also protect cumulative research. If one dataset later becomes unavailable, an independently preserved documentary or relational source can retain part of the evidential architecture. If one formalization proves inappropriate, a narrative or historical reconstruction can preserve the empirical structure needed for reinterpretation. This resilience links methodological redundancy to preservation and future re-epistemization.

9.8.9 Methodological Economy

Methodological economy concerns the disciplined limitation of a portfolio to methods whose contributions justify their evidential, computational, interpretive, ethical, and coordination costs. Its role is to balance methodological pluralism with tractable research design. The objective is to preserve enough methodological diversity to ad-

dress the project's inferential needs while avoiding accumulation that produces little additional leverage. The method is marginal and architectural: each added method is evaluated by the new distinction, uncertainty reduction, robustness information, or revision capacity it contributes.

Methodological economy is especially important in large interdisciplinary projects because every additional method creates interfaces. Concepts need translation, data require alignment, temporal and spatial boundaries may differ, outputs require adjudication, and conflicting assumptions need documentation. A method can be individually sophisticated while reducing project coherence if its role cannot be connected to the central question.

Economy therefore begins with the core-method contract and supporting-method roles. A candidate method should address a known inferential gap, blind spot, robustness dimension, or representation loss. If the same function is already supplied adequately by another method, additional redundancy should be justified by independent failure modes or preservation value. Methods that add complexity without changing the warranted claim can remain outside the active portfolio.

Proposition 9.100 (Marginal methodological value). *An additional method strengthens a research portfolio when its expected contribution to inference, discrimination, robustness, preservation, or revision exceeds the coordination and interpretive costs introduced by integrating it with the existing architecture.*

This proposition does not require a numerical cost-benefit calculation. It provides a design question: what becomes knowable, testable, revisable, or preservable because the method has been added? If the answer remains unclear, the portfolio can be simplified.

Methodological economy also supports epistemic humility. A project can leave some questions unresolved rather than adding increasingly elaborate methods to create an appearance of completeness. Explicit incompleteness can be preferable to weakly integrated abundance. The portfolio should therefore state which evidential gaps remain after method selection and which future methods could address them if the research question later expands.

The method portfolio established in this section provides the components that Section 247 will place into temporal and logical sequence. Core, supporting, interpretive, quantitative, formal, historical, and computational methods can enter at different stages, recur after new evidence, or change role as the project evolves. Productive redundancy and methodological economy provide the constraints through which that sequencing remains both plural and coherent.

9.9 Sequencing of Methods

This section develops the temporal and logical architecture through which the method portfolio of Section 9.8 is organized into an executable research process. Its role in Chapter 9 is to specify how methods enter, follow, revise, constrain, and sometimes reconfigure one another across a research cycle. The objective is to make methodological order explicit because the output of one method frequently becomes the object, data, prior, boundary condition, hypothesis, or validation target

of another. The discussion proceeds through exploratory, interpretive, quantitative, historical, formalization, simulation, intervention, recursive, and adaptive sequences. The mode of argument is architectural and comparative: each sequence is evaluated by the inferential function it serves, the dependencies it creates, the information it preserves, and the revision pathways it leaves open.

Method sequencing matters because earlier methodological operations can shape the conditions under which later ones operate. An interview study conducted before variable construction can reshape the categories later measured quantitatively. A quantitative anomaly can motivate historical reconstruction that changes the periodization of the project. A formal model developed before fieldwork can sharpen observation by identifying discriminating variables, while a model imposed too early can narrow attention around distinctions that the field does not support. Simulation can expose hidden assumptions in a mechanism account, and intervention can generate new evidence that reopens earlier questions. The same set of methods can therefore constitute different research designs depending on their order and the interfaces among them.

A sequence should also preserve the status of intermediate outputs. Exploratory categories can remain provisional even when later methods use them. A historical reconstruction can provide a temporal constraint without becoming a complete causal explanation. A formalization can guide measurement while remaining a representation rather than an ontology. A simulation can identify possible trajectories without becoming historical evidence. Explicit sequencing helps prevent later stages from laundering provisional outputs into stronger epistemic status merely because they have passed through several methodological transformations.

Definition 9.101 (Method sequence). A *method sequence* is a documented ordering of methodological operations in which each stage has a specified input, output, inferential role, dependency on prior stages, and rule for revising earlier stages when later evidence or analysis materially changes the research architecture.

Definition 9.101 treats sequencing as more than chronology. Two methods can operate concurrently while remaining ordered by inferential dependence: one may require categories produced by another, or both may depend on a common historical reconstruction. Conversely, methods performed at different calendar times can be analytically parallel when neither supplies inputs to the other. A defensible sequence therefore records logical dependency separately from practical scheduling.

A useful sequencing plan identifies at least four relations among methods. The first is *input dependence*: which outputs from an earlier method become inputs to a later one. The second is *constraint*: which findings narrow the admissible interpretations or models available later. The third is *validation or confrontation*: which method is used to test, challenge, or qualify another method's output. The fourth is *revision*: which later findings can reopen an earlier decision about object construction, representation, data, or method choice. These relations can form a directed acyclic sequence in a tightly staged project or a recurrent network in an adaptive design.

Proposition 9.102 (Sequencing transparency). A *multimethod research design becomes more interpretable when the project records which methodological outputs are passed forward, which assumptions are inherited, which findings can revise prior*

stages, and which claims depend on the order in which the methods were applied.

Proposition 9.102 also creates a basis for cross-method adjudication. Apparent disagreement can arise because methods addressed different stages of an evolving object, because one method inherited categories produced by another, or because later analysis revealed a change in scale or boundary. The sequence therefore becomes part of the evidential record rather than an administrative detail.

9.9.1 Exploratory Sequence

An exploratory sequence organizes methods around the discovery and stabilization of a researchable object before stronger inferential commitments are made. Its role is to widen empirical and conceptual access at the beginning of a project, identify salient distinctions, locate evidence, generate candidate mechanisms, and determine which representations are sufficiently faithful for later inquiry. The objective is to move from a broad problem architecture toward a more specific question, object, field, data architecture, and method portfolio without treating early observations as settled findings. The sequence typically privileges flexible methods whose outputs can remain provisional and revisable.

Exploration can begin with documentary review, field observation, interviews, descriptive statistics, network mapping, archival reconnaissance, pilot coding, or simple computational inspection. The appropriate starting point depends on the object and field. A project studying an unfamiliar institution can begin by mapping documents, actors, procedures, and terminology. A project working with a large secondary dataset can begin with provenance analysis, missingness inspection, descriptive distributions, and comparison of variable definitions across periods. A project concerned with a new relational process can begin with qualitative mapping of relation types before constructing a network representation.

The exploratory sequence should preserve breadth long enough to reveal alternative object definitions. Early closure can convert the first visible manifestation into the research object itself. A category present in administrative data may omit a relation that actors treat as central. A recurring interview theme may be a consequence of the sampling field rather than a general property. A visually prominent cluster in network data may disappear under another boundary definition. Exploratory sequencing therefore benefits from deliberately comparing several provisional representations before selecting the one that will carry stronger inference.

Definition 9.103 (Exploratory-method sequence). An *exploratory-method sequence* is an ordered set of low-commitment methodological operations designed to discover candidate objects, categories, relations, mechanisms, evidence sources, boundaries, and representations while preserving the possibility of revising the research question before confirmatory or strongly attributive analysis begins.

Exploration should also establish transition criteria. A project can remain indefinitely exploratory if every anomaly reopens the entire design. The sequence therefore benefits from specifying what evidence is sufficient to stabilize a provisional object or move a candidate mechanism into targeted testing. Such criteria need not require certainty. They can require, for example, convergence across several sources, stable operational definitions across pilot cases, or adequate evidence that a selected

representation preserves the distinctions central to the question.

The output of exploratory sequencing is therefore a documented provisional architecture rather than a final conclusion. It includes candidate questions, field and case boundaries, source maps, data limitations, initial representations, plausible mechanisms, unresolved alternatives, and a reasoned decision about which methods should follow. These outputs become inputs to interpretive, quantitative, historical, formal, or mixed sequences while retaining their provisional provenance.

9.9.2 Interpretive Sequence

An interpretive sequence places meaning, classification, institutional language, situated understanding, and symbolic mediation early enough in the research process to shape later object construction and measurement. Its role is to identify how actors and institutions distinguish relevant categories, interpret rules, recognize events, assign value, and construct practical meanings that later methods may encode more abstractly. The objective is to prevent later quantitative or formal stages from treating categories as self-interpreting when their empirical significance depends on historical or relational context.

Interpretive sequencing often begins with close reading, interviews, observation, discourse analysis, legal or institutional interpretation, or reconstruction of classificatory practice. These methods can reveal that apparently stable terms carry different meanings across organizations or periods. They can also show that one recorded behavior corresponds to several practical intentions or that formally identical rules are enacted differently across fields. Such findings can change what should be measured, which cases are comparable, and how variables or relation types should be defined.

Interpretive work can precede quantitative analysis when semantic validity is a major design risk. For example, a project can first reconstruct the institutional meanings of a status category and then decide which administrative codes can approximate that category quantitatively. Interpretation can also follow quantitative analysis when an observed pattern requires contextual explanation. The sequencing choice depends on whether meaning is required to construct the measurement architecture or primarily to understand an already identified pattern.

Proposition 9.104 (Interpretation-before-compression). *When a later method compresses historically or institutionally heterogeneous meanings into variables, categories, or formal types, interpretive work gains design value when it occurs early enough to identify which distinctions should be preserved before that compression is fixed.*

Interpretive sequencing can also be recursive. A preliminary interpretation can guide sampling, later field encounters can challenge that interpretation, and the revised interpretation can alter coding or model structure. The important design requirement is to distinguish interpretation that helped construct a representation from interpretation used after analysis to explain the result. Both are legitimate, but they occupy different places in the inferential chain.

The output of an interpretive sequence should therefore include semantic definitions, category histories, actor- or institution-specific meanings, documented ambi-

guities, translation rules into other representations, and a record of distinctions that remain difficult to formalize. These outputs can become inputs to tabular coding, graph typing, formal models, or historical comparison while preserving the interpretive remainder identified in Section 9.7.

9.9.3 Quantitative Sequence

A quantitative sequence organizes methods around measurement, numerical comparison, estimation, uncertainty, and structured analysis of variation. Its role is to specify when numerical operations enter the research design, how variables are constructed from the data architecture of Section 9.6, which inferential targets they address, and how quantitative results redirect later inquiry. The objective is to ensure that numerical analysis inherits explicit object definitions and provenance while remaining capable of revealing patterns that motivate additional interpretation, historical reconstruction, or mechanism testing.

A common quantitative sequence begins with descriptive analysis, proceeds to measurement validation and comparison, then advances toward estimation, causal design, longitudinal modeling, network statistics, or another target-specific method. This order is useful because advanced models can conceal basic category or data-quality problems. Descriptive distributions can reveal truncation, institutional discontinuities, extreme concentration, or subgroup heterogeneity that later models should accommodate. Missingness analysis can reveal that observation itself is generated by institutional access or exit.

Quantitative sequencing can also begin after qualitative or historical work has stabilized the relevant variables. In such a design, the earlier methods supply category definitions, plausible mechanisms, and comparison structures. The quantitative stage then tests prevalence, distribution, magnitude, or temporal pattern. Later qualitative or historical follow-up can investigate cases that deviate from the estimated pattern, thereby creating a return path from numerical analysis to process reconstruction.

Definition 9.105 (Quantitative-method sequence). A *quantitative-method sequence* is a documented progression from measurement and data-quality assessment toward numerical comparison or estimation in which each stage specifies the variables, target quantity, population or relational scope, uncertainty representation, assumptions, and criteria for redirecting inquiry when the numerical pattern challenges the current research architecture.

Quantitative sequences should distinguish exploratory and confirmatory roles. Searching many model specifications can be appropriate during discovery, while later inferential claims require a transparent record of which specifications were selected and why. Sensitivity analysis can be built into the sequence rather than appended after the preferred result. Likewise, the sequence should record whether a new variable was constructed after seeing an outcome pattern, whether a subgroup was defined post hoc, or whether a time window changed because of an observed break.

The quantitative stage can therefore function both as measurement and as diagnosis. Strong average regularity can motivate mechanism inquiry; a weak average

can conceal heterogeneous trajectories; a structural break can trigger historical periodization; and an unexpected null can reveal that the representation omitted a mediating relation. Sequencing keeps these redirects visible rather than presenting the final model as though it had been specified independently of the empirical path that produced it.

9.9.4 Historical Sequence

A historical sequence organizes methods around temporal formation, event order, category change, institutional layering, contingency, and path dependence. Its role is to construct the historically situated architecture within which other methods acquire meaning. The objective is to identify antecedent conditions, turning points, changing boundaries, recording regimes, and alternative paths before later methods treat current categories or institutions as stable analytical objects. The sequence can serve as the core design for historically oriented projects or as a preparatory layer for quantitative, formal, and computational inquiry.

Historical sequencing commonly begins with periodization and source mapping. The researcher identifies the temporal horizon, relevant archives or records, known institutional transitions, and periods in which data production or category definitions changed. Event reconstruction then establishes a partial or total chronology depending on evidential resolution. Process tracing can locate intermediate transformations, while comparative historical analysis can identify whether similar outcomes arose through different sequences.

This sequence is especially important when data extend across institutional change. A variable with the same label can represent different practices before and after reform. A relation can change legal status while retaining practical continuity, or a formal category can remain stable while implementation changes. Historical inquiry placed early in the sequence can identify such discontinuities before they are smoothed into one quantitative series or encoded as fixed model parameters.

Historical work can also follow another method. A statistical discontinuity, network transition, or surprising simulation mismatch can motivate archival investigation of the period in which the divergence occurred. In such cases, the historical sequence is targeted by a prior result. The project should record this dependency because the archive search is now conditioned by an anomaly already observed in another representation.

Proposition 9.106 (Historical-sequence anchoring). *A historical sequence strengthens integrated design when it establishes the temporal identity of categories, institutions, relations, and observations before methods that assume their continuity, and when later historical follow-up remains available to investigate breaks revealed by those methods.*

The output of historical sequencing includes periodization, event-order constraints, institutional genealogies, changing category definitions, source-provenance maps, and plausible alternative pathways. These outputs can anchor longitudinal data, formal transition rules, historical simulations, and counterfactual analysis while preserving uncertainty about unobserved intervals.

9.9.5 Formalization Sequence

A formalization sequence organizes the transition from verbal, historical, empirical, or interpretive accounts into explicit mathematical, logical, graphical, or categorical structure. Its role is to determine when formal commitments are introduced and how they are revised in response to evidence. The objective is to ensure that formal objects clarify the research problem, expose assumptions, and generate discriminating implications while remaining traceable to the representations and evidence from which they were constructed.

Formalization can occur early when the research question is fundamentally structural. A project concerned with partial order, network reachability, equivalence, or dynamical stability can use formal representation from the beginning to identify what must be observed. Early formalization can reveal missing variables, incompatible assumptions, or non-identifiability before expensive data collection occurs. The formal model then functions as a design instrument rather than merely a final presentation device.

Formalization can also occur after empirical reconstruction. Historical or qualitative work can first identify candidate mechanisms, relation types, or event sequences. The researcher then formalizes these structures to test compositional consistency, derive implications, or compare alternative mechanisms. This order is particularly useful when the target domain is poorly understood and early formal commitment would risk imposing inappropriate categories.

Definition 9.107 (Formalization sequence). A *formalization sequence* is the documented progression through which analytically interpreted objects and relations are translated into explicit formal structures, used to derive or compare implications, confronted with evidence, and revised when formal assumptions or empirical correspondence prove inadequate.

The sequence should preserve the distinction between model revision and theory revision. A failed formalization can indicate that the chosen mathematical structure is inappropriate even when the underlying theoretical concept remains useful. Conversely, repeated failure across several reasonable formalizations can reveal ambiguity or instability in the theoretical term itself, activating the theory-revision pathway developed in Section 9.3.

Formalization can therefore iterate with measurement and interpretation. A model can identify a theoretically important state transition, prompting new data collection. Empirical results can reveal that an assumed symmetry is absent or that a transition rule changes historically. The formal structure can then be weakened, expanded, or split by regime. Sequencing makes these changes auditable and prevents the final formal model from concealing the path by which its assumptions were selected.

9.9.6 Simulation Sequence

A simulation sequence organizes the progression from a specified generative representation to executable dynamics, calibration or initialization, computational exploration, validation, and comparison with empirical or historical evidence. Its role is

to clarify what simulation contributes at each stage of a project and to distinguish model-generated behavior from observations of the target domain. The objective is to use simulation to expose mechanism implications, explore path dependence, compare alternative histories, or test sensitivity while preserving the provenance of the rules and parameters that generate the simulated trajectories.

Simulation normally requires earlier representational work. Agents, state variables, relations, transition rules, institutions, boundaries, or historical initial conditions must be defined before the model can run. These elements can come from theory, qualitative inquiry, data analysis, historical reconstruction, or formal derivation. The simulation sequence should record which source supplied each component because the evidential status of a simulated result depends partly on the status of its inputs.

A disciplined sequence separates construction, calibration, exploration, and validation. Construction specifies the mechanism architecture. Calibration or initialization links selected components to empirical values or plausible ranges. Exploration examines trajectories across conditions, parameters, stochastic realizations, or alternative rules. Validation compares model behavior with empirical patterns that were not used merely to force the simulation to fit. These stages can iterate, yet their functions should remain distinguishable.

Simulation can also redirect earlier methods. A model can show that two candidate mechanisms produce indistinguishable aggregate outcomes but diverge in an unmeasured intermediate relation. That result can motivate targeted data collection. A historical simulation can reveal that only a narrow event order reproduces the documented sequence, prompting archival investigation of the uncertain interval. A network simulation can identify a structural threshold, motivating analysis of real-world topology near that threshold.

Caution 9.108 (Simulation-sequence provenance). Model-generated states should retain a provenance distinct from observed, historically reconstructed, or inferred states throughout the simulation sequence, including when simulated outputs are later reused as inputs to another method.

This caution is especially important in recursive workflows. A simulated trajectory can become a hypothesis generator, a comparison case, or a source of synthetic data for testing an algorithm. It does not become empirical evidence about the target system through reuse. Sequencing preserves this distinction while still allowing computational outputs to participate productively in integrated design.

9.9.7 Intervention Sequence

An intervention sequence organizes inquiry around deliberate or naturally occurring changes that generate evidence about mechanisms, causal contrasts, adaptation, or practical consequences. Its role is to specify when intervention enters a research design, which prior evidence justifies the intervention, what is measured before and after action, and how intervention-generated evidence feeds back into the project. The objective is to coordinate design, ethics, baseline construction, implementation, observation, adaptation, and interpretation without reducing intervention to a single treatment indicator.

Intervention sequencing usually requires preparatory stages. The research object and field should be sufficiently understood to identify who or what will be affected. Baseline measurement should correspond to the expected mechanism and outcome horizon. Ethical and governance review should address foreseeable risks, asymmetries, reversibility, and data responsibilities. A pilot intervention can test implementation fidelity and reveal unexpected pathways before a larger intervention proceeds.

The intervention itself should be recorded as a generative event with provenance. Intended treatment, enacted treatment, uptake, adaptation, spillover, institutional response, and unintended effects can diverge. Measuring only assignment and end-point can miss the process that produced the observed difference. Intervention sequences therefore benefit from embedded process tracing, relational observation, and longitudinal follow-up when the research question concerns mechanism or generative consequences.

Intervention can also transform the field in ways that alter later measurement. Participants learn, institutions adapt, researchers gain visibility, and categories can change in response to the intervention. These changes can be substantively important rather than statistical nuisance. The sequence should therefore record whether later observations still refer to the same object and whether the intervention changed the generative rule or only one state within a stable rule structure.

Proposition 9.109 (Intervention-sequence completeness). *An intervention sequence gains interpretive adequacy when it connects pre-intervention object and baseline construction, intervention provenance, implementation and uptake, intermediate process evidence, downstream outcomes, unintended effects, and post-intervention revision of the research architecture.*

Intervention sequences can move a project toward application-dominant praxis when practical consequence becomes the organizing problem. Within research-dominant praxis, intervention can remain primarily epistemic when the central objective is to learn how a generative mechanism operates under controlled or naturally varying conditions. The sequence should state which orientation governs the design.

9.9.8 Recursive Sequence

A recursive sequence organizes methods so that later outputs intentionally return to revise earlier stages. Its role is to formalize the recurrent structure that appears throughout Generative Relational research: evidence revises representation, representation revises method choice, method results revise the question, and revised questions redirect evidence collection. The objective is to make recursion auditable rather than allowing iterative research to appear as an undocumented series of ad hoc adjustments.

Recursion is appropriate when the object is only partially known, categories evolve, methods reveal their own blind spots, or the system under study changes during inquiry. A project can begin with an exploratory representation, collect data, discover that the boundary is inadequate, redefine the object, and repeat measurement. A formal model can reveal an unobserved mechanism component, leading to new interviews or archival work. A quantitative analysis can identify a deviant subgroup,

prompting case reconstruction that changes the theoretical account.

The recursive sequence should specify return conditions. A project that reopens every design choice after every new observation becomes unstable. Return can be triggered by predefined events such as failed validation, large representation loss, contradictory evidence, unexpected structural breaks, or sensitivity to a plausible alternative boundary. The return path should also specify which prior outputs remain usable and which require reanalysis under the revised architecture.

Definition 9.110 (Recursive-method sequence). A *recursive-method sequence* is a documented research architecture in which later methodological outputs can trigger specified revisions of earlier questions, objects, boundaries, data structures, representations, or methods, with the consequences of those revisions propagated through dependent stages.

Versioning is central to recursive sequencing. The project should retain earlier question formulations, variable definitions, boundary choices, and model versions rather than overwriting them. This preservation allows the researcher to distinguish genuine theoretical development from silent drift and permits later readers to reconstruct why a particular inferential path was abandoned or revised.

Recursive sequencing also supports learning across methods. A method can fail in an informative way. An interview protocol can reveal that a theoretical term is unintelligible to participants. A network model can fail because the tie definition merges distinct relations. A simulation can remain robust only under implausible parameter values. These failures become inputs to the next cycle when their provenance and consequences are recorded.

9.9.9 Adaptive Sequence

An adaptive sequence permits the method order itself to change in response to evidence, field conditions, resource constraints, ethical developments, or evolving research questions. Its role is to provide disciplined flexibility when the original sequence becomes inefficient, infeasible, or epistemically misaligned. The objective is to define how sequencing decisions can change while preserving the traceability required for later interpretation and reproducibility. Adaptive sequencing is therefore a governance problem as well as a methodological one.

Adaptation can concern timing, method role, sampling, data acquisition, model complexity, or the threshold for moving between stages. A project can postpone formalization until interpretive ambiguity is reduced. It can bring historical work forward after discovering a category discontinuity. It can replace a planned intervention with observational comparison when ethical conditions change. It can promote a supporting method to core status when new evidence reveals that the original inferential bottleneck lies elsewhere.

Adaptive sequencing differs from unstructured opportunism through explicit decision rules. The project should record the condition that motivated the change, the alternatives considered, the consequences for earlier results, and the parts of the research architecture that now require revision. Where practical, adaptation criteria can be specified prospectively. In exploratory research, they can remain broader but

should still be documented when activated.

Definition 9.111 (Adaptive sequencing rule). An *adaptive sequencing rule* specifies the conditions under which the order, role, timing, or inclusion of methods may change during a project, together with the documentation and reanalysis required to preserve the interpretability of results produced before and after the change.

Adaptive sequencing also interacts with methodological economy. A method can be removed when its expected information gain falls below its coordination cost or when another method has already resolved the inferential uncertainty it was meant to address. Additional methods can be introduced when a new evidential gap becomes consequential. The portfolio and its sequence therefore co-evolve under explicit design governance.

The nine sequencing forms developed in this section are compatible rather than mutually exclusive. A project can begin with an exploratory sequence, use interpretive and historical work to stabilize categories, move into quantitative and formal analysis, run simulations, and retain recursive or adaptive return paths throughout. The relevant design question is which sequence best addresses the current inferential bottleneck while preserving provenance and revisability. Once several methods have produced findings, the next architectural problem concerns how those findings should be compared when they converge, diverge, or conflict. That problem motivates the cross-method adjudication developed in the following section.

9.10 Cross-Method Adjudication

The preceding sections specified how a Generative Relational research project composes a method portfolio and organizes the sequence through which methods enter inquiry. The role of the present section is to govern the next project-level problem: how method-specific findings should be compared once several evidential pathways have produced claims, measurements, reconstructions, interpretations, or model outputs that bear on the same research architecture. Its objective is to distinguish convergence, divergence, contradiction, unequal evidential strength, method-specific blind spots, and irreducible disagreement; to connect each condition to an appropriate adjudicative response; and to specify how conflicts can trigger revision without being prematurely dissolved. The discussion proceeds from compatible findings toward progressively stronger forms of tension and closes with revision and preservation. The method of argument is diagnostic and architectural: findings are compared through their inferential targets, evidential provenance, assumptions, boundaries, scales, temporal scopes, representations, and failure modes before any project-level synthesis is attempted.

Cross-method adjudication extends the relational triangulation developed in Chapter 7 and the cross-method robustness developed in Chapter 8. Triangulation asks how partially distinct evidential pathways bear on a relational claim. Cross-method robustness asks whether a claim remains warranted across methods with sufficiently differentiated assumptions and vulnerabilities. Project-level adjudication adds a decision layer. It asks what the research architecture should retain, qualify, revise, reopen, or preserve when those pathways have already produced findings. This distinc-

tion matters because the existence of several methods does not itself determine how their outputs should be integrated.

Established work on triangulation and mixed-method design already cautions against equating methodological plurality with simple confirmation. Different methods can provide complementary access to a problem, while inconsistency and contradiction can remain legitimate outcomes requiring interpretation rather than forced convergence (Jick 1979; Creswell and Plano Clark 2018; Mathison 1988). Generative Relational research adds several sources of heterogeneity to this problem. Methods can access different manifestations of a relation, operate at different scales, preserve different temporal structures, encode different boundaries, privilege different categories, and carry different transformation losses. Their outputs therefore become commensurable only after the project identifies which parts of the underlying claim they actually address.

Definition 9.112 (Cross-method adjudication). *Cross-method adjudication* is the documented project-level process through which findings from methodologically differentiated forms of inquiry are aligned by inferential target, compared in light of their evidence, assumptions, scope, provenance, and failure modes, and assigned consequences for synthesis, qualification, revision, preservation, or further inquiry.

Definition 9.112 uses adjudication in a procedural sense. It does not presume that every conflict has one method-independent winner. A valid adjudicative result can be convergence, differentiated complementarity, asymmetric evidential weighting, narrowing of a claim, revision of the research object, preservation of several interpretations, or recognition that the available evidence remains insufficient for closure.

Table 9.1 summarizes the principal states developed in this section and the project responses they normally motivate.

The table makes two general principles explicit. First, adjudication concerns claim components rather than whole methods. A historical reconstruction can be stronger for sequence while a quantitative analysis is stronger for distributional scope. Second, conflict is informative only when the project knows what is conflicting. Apparent methodological disagreement can arise from different questions, objects, scales, periods, or representations. Adjudication therefore begins with alignment before it proceeds to weighting or revision.

9.10.1 Convergent Findings

Convergent findings occur when methodologically differentiated forms of inquiry support sufficiently compatible components of a research claim. Their role in adjudication is to identify where several evidential pathways provide mutual constraint without treating agreement as automatic validation. The objective is to determine whether convergence reflects genuinely differentiated access to the target or merely repeated use of the same upstream evidence, categories, assumptions, or representation. Convergence is therefore evaluated through provenance and inferential alignment as well as surface agreement.

A project can observe convergence at several levels. Methods can agree that a relation exists, that a mechanism is active, that a sequence occurred in a particular or-

Table 9.1: Cross-method adjudicative states and characteristic project responses

Adjudicative state	Diagnostic condition	Project response	Closure requirement
Convergence	Compatible findings address aligned components of a claim through sufficiently differentiated pathways	Strengthen the supported component while retaining provenance and residual uncertainty	Shared dependencies, scope, and representation loss remain visible
Divergence	Findings differ because methods access distinct dimensions, scales, periods, standpoints, or manifestations	Differentiate the claim, revise translation, or preserve complementarity	The locus of difference is identified before synthesis
Contradiction	Findings remain materially incompatible after relevant scope and representation differences are aligned	Localize the conflict and inspect evidence, assumptions, object specification, mechanism, and theory	Incompatibility survives a documented alignment audit
Unequal strength	Competing findings have different evidential quality, independence, relevance, or vulnerability	Weight conclusions asymmetrically and state the basis of the weighting	Weight follows warrant rather than method prestige or numerical count
Blind-spot exposure	One method reveals a domain that another systematically cannot observe or represent	Amend the portfolio, narrow the affected claim, or revise the object and representation	The blind spot is linked to a specific access or representation limitation
Irreducible disagreement	Plausible interpretations remain incompatible after reasonable diagnostic and evidential work	Preserve multiple interpretations and propagate uncertainty downstream	Shared evidence, divergent assumptions, and reopening conditions are recorded
Revision-triggering conflict	Conflict indicates that an upstream design choice is unstable	Return to the relevant question, object, boundary, data, representation, method, or theory	Dependencies of the revised component are re-examined

der, that an effect changes across positions, that a structural transition took place, or that a candidate explanation is inconsistent with the evidence. These forms of agreement should remain distinct. Agreement about existence does not establish agreement about mechanism, and agreement about direction does not establish agreement about magnitude or scope.

Convergence becomes more informative when methods have partially independent failure modes. Documentary reconstruction and interviews can support a common sequence while differing in production conditions. A longitudinal model and ethnographic observation can support the existence of a structural shift while accessing different manifestations. Historical analysis and simulation can support the plausibility of one mechanism when the historical record supplies sequence constraints and the simulation establishes generative capability under independently defensible assumptions. The methods contribute different kinds of warrant even when the resulting claim is compatible.

Dependence among pathways reduces the incremental value of agreement. Several models fitted to one dataset can reproduce the same measurement error. Interviews and institutional documents can repeat a shared organizational narrative. A computational classification can inherit labels produced by the same administrative system later used for validation. Project-level adjudication should therefore ask whether the paths are merely technically distinct or epistemically differentiated in the dimensions relevant to the claim.

Definition 9.113 (Convergence profile). A *convergence profile* records the claim component on which methods agree, the evidential and representational pathway sup-

porting each finding, shared upstream dependencies, remaining differences in scope or interpretation, and the additional warrant contributed by the observed agreement.

The convergence profile protects against global language such as “all methods confirm the theory.” A project can instead report that independent historical and relational evidence converge on the timing of institutional restructuring, while the magnitude and downstream mechanism remain uncertain. Such reporting is stronger because it specifies what the convergence actually warrants.

Convergence can also expose a common blind spot. If every method shares the same boundary, category system, or preserved archive, agreement can stabilize a distorted representation. The project should therefore pair convergence analysis with an explicit search for shared exclusions. Confidence can increase when findings converge across pathways whose differences are relevant to the possible error being tested.

Proposition 9.114 (Qualified convergence). *Cross-method convergence strengthens a project-level claim to the extent that the findings address aligned claim components and arise through sufficiently differentiated evidential, representational, or inferential pathways whose shared dependencies are understood.*

9.10.2 Divergent Findings

Divergent findings differ without yet establishing contradiction. Their role in cross-method adjudication is to reveal dimensions of the research object that have been separated by method, scale, time, standpoint, category, or representation. The objective is to determine whether the difference reflects legitimate complementarity, an unresolved translation problem, or an early indication of stronger conflict. Divergence should therefore be decomposed before the project attempts reconciliation.

Several forms recur. A legal analysis can identify formal authority while ethnography identifies practical dependence elsewhere. Network analysis can show a structurally central actor while interviews show limited perceived legitimacy. Aggregate quantitative evidence can indicate stability while local historical reconstruction identifies disruptive reorganization. A short observational window can show adaptation while a longer historical window shows cumulative constraint. These findings differ because they concern distinct relational or generative dimensions.

Divergence can be productive when each method reveals a component that the others are not designed to recover. The project can then construct a differentiated account in which formal authority, practical coordination, perceived legitimacy, and resource dependence remain analytically distinct. Such differentiation often improves the research object because the initial concept may have compressed several relations into one category.

Representation architecture is especially important here. Section 9.7 treated narrative, tabular, graph, geometric, field, algebraic, dynamical, spacetime, and multiple representations as selective encodings. A divergence between methods can arise because one representation preserves sequence while another preserves topology, or one preserves actor meaning while another preserves distributional pattern. Translation should therefore identify which distinctions survive movement between rep-

representations and which become residual.

A useful adjudicative response is to construct a divergence map. The map locates each finding by object, property, manifestation, standpoint, boundary, scale, temporal window, and inferential target. Findings that initially appear incompatible can then become complementary once they are placed in distinct coordinates. Findings that remain incompatible after this alignment move into the stronger category of contradiction developed in the following subsection.

Definition 9.115 (Divergence map). A *divergence map* records where method-specific findings differ across object specification, relational or generative property, manifestation, standpoint, boundary, scale, temporal scope, representation, and inferential target, together with the translations required to compare them.

The map also prevents a common methodological asymmetry. Quantitative findings should not automatically define the common language into which qualitative or historical findings are translated, and interpretive findings should not automatically determine the substantive meaning of every measured pattern. The translation interface itself is a design choice and should remain visible.

Divergence can motivate theory development without implying theoretical failure. A theory that expected one relation may need to distinguish formal, enacted, and perceived forms. A mechanism stated at one scale may require a cross-scale bridge. A stable category may need historical versioning. In this sense, divergence can increase conceptual resolution by showing where the project's original language was too coarse.

9.10.3 Contradictory Findings

Contradictory findings arise when method-specific claims remain materially incompatible after the project has aligned the dimensions necessary for comparison. Their role in adjudication is diagnostic: contradiction identifies a location where the existing research architecture cannot retain all current claims simultaneously under the same specified conditions. The objective is to localize the incompatibility before deciding whether it reflects evidential error, measurement failure, representation mismatch, object instability, mechanism plurality, or theoretical inadequacy.

Contradiction should therefore be a late classification rather than an immediate reaction to differing results. The project first asks whether the findings concern the same object and relation, the same boundary and scale, comparable temporal intervals, compatible definitions, and the same inferential target. A finding that one policy has legal force and another that it has weak practical enactment can coexist. A finding that an aggregate effect is positive and another that one subgroup experiences a negative effect can also coexist. Contradiction becomes stronger when the same claim component receives incompatible support under sufficiently aligned conditions.

Chapter 7 introduced contradiction localization for relational evidence. At the project level, localization expands to the full design chain. A contradiction can originate in data production, measurement, category construction, representation, method assumptions, inferential rules, or the theory connecting those elements. The relevant response is therefore not necessarily to discard one finding. The project

should identify the smallest upstream component whose revision can explain the conflict without disturbing well-supported parts of the architecture.

Contradictions can also expose temporal change. Methods conducted at different points in an evolving system can both be accurate relative to their observation periods while appearing inconsistent when time is suppressed. An institution can move from centralized to distributed coordination, a category can change meaning, or a relation can shift from enabling to constraining under altered conditions. Historical alignment should therefore precede any claim that two methods disagree about one stable object.

When contradiction persists, the project should specify the discriminating evidence that would matter. One interpretation may predict an intermediate mechanism trace absent from the other. Two representations may imply different responses to a boundary change. Competing historical accounts may require different sequence relations. Formal models may generate similar endpoints but different transitional structures. These discriminators convert contradiction from a rhetorical problem into a research agenda.

Definition 9.116 (Project conflict record). A *project conflict record* identifies the incompatible findings, the dimensions already aligned, their evidential provenance and dependencies, the assumptions required by each interpretation, candidate sources of conflict, discriminating evidence, and the consequences of retaining the disagreement for downstream claims.

The conflict record also supports later audit. If subsequent evidence resolves the contradiction, the project can reconstruct why the earlier state was underdetermined. If the conflict persists, the record becomes part of the preserved epistemic history rather than disappearing from the final synthesis.

Proposition 9.117 (Conflict localization before resolution). A *project should treat cross-method contradiction as a reason for targeted diagnostic work when incompatible findings survive relevant alignment of object, scope, time, representation, and inferential target; the appropriate revision depends on the localized source of the incompatibility.*

9.10.4 Unequal Evidential Strength

Cross-method plurality does not imply evidential equality. The role of this subsection is to specify how a project can weight findings asymmetrically while preserving methodological pluralism. The objective is to distinguish warranted asymmetry from hierarchy based on disciplinary prestige, technical complexity, sample size alone, rhetorical vividness, or researcher preference. Evidential weight should be claim-relative and should track the quality of the inferential pathway connecting evidence to the specific conclusion under consideration.

Several dimensions can justify unequal weight. Evidence can differ in directness, provenance quality, independence, measurement validity, temporal correspondence, boundary adequacy, sample coverage, access to the relevant mechanism, sensitivity to plausible alternatives, and vulnerability to missingness or model specification. The importance of each dimension depends on the claim. A large dataset can carry strong

weight for prevalence while offering weak access to historical mechanism. A small number of well-provenanced archival records can carry strong weight for the date of an institutional decision while providing little basis for population-level distribution.

Adjudication should therefore separate method identity from evidential function. The project asks which finding has stronger warrant for this claim component, under these conditions, for this scope. A method can be strong for one component and weak for another. This claim-relative approach also allows asymmetric synthesis: the project can privilege one finding for sequence, another for meaning, and another for distribution without constructing a total ranking of methods.

Methodological independence also affects weight. Agreement between five analyses using one dataset and one measurement system can add less warrant than agreement between two genuinely differentiated evidential pathways. Conversely, one source with unusually direct access to the target can outweigh several indirect proxies. Numerical multiplicity should therefore remain distinct from evidential multiplicity.

A transparent weighting record can state the dimensions on which one finding receives greater project-level weight. The record need not reduce warrant to a universal scalar score. In many cases a qualitative profile is more faithful because strengths can be multidimensional and partially incommensurable. What matters is that the basis for asymmetry is explicit and revisable.

Definition 9.118 (Claim-relative evidential weighting). *Claim-relative evidential weighting* is the assignment of differentiated project-level importance to method-specific findings according to the evidential properties relevant to a specified claim component, with the basis, scope, and uncertainty of the weighting made explicit.

This principle also protects minority or difficult-to-record evidence. A method with limited coverage can reveal a relation systematically excluded from administrative data. Its evidence should not be dismissed because another method produces more observations. The appropriate response is to assess what each pathway can warrant and whether the omission identified by the smaller pathway changes interpretation of the larger one.

9.10.5 Method-Specific Blind Spots

Every method makes some structures visible and leaves others weakly observed, transformed, or inaccessible. The role of blind-spot analysis is to connect these limitations to project design rather than treating them as generic caveats. The objective is to identify when a disagreement or unexplained residual arises because a method systematically lacks access to a relevant dimension of the object. Blind spots can concern evidence production, temporal resolution, relational boundary, scale, meaning, mechanism, higher-order structure, or the representation through which findings are expressed.

A cross-sectional dataset can obscure sequence and path dependence. Archival sources can underrepresent actors whose activities generated few durable records. Interviews can reveal experience and interpretation while remaining limited for estimating prevalence. Network analysis can preserve tie structure while compressing

the meaning and quality of ties. A simulation can explore consequences of explicit rules while remaining blind to processes omitted from the rule set. A formal model can reveal implications of assumptions while remaining silent about whether the assumptions correspond adequately to the empirical target.

Blind spots become especially consequential when methods mutually inherit them. Several datasets can share the same institutional categories. Several historical accounts can rely on the same archive. Several computational models can use one operationalization of relation strength. Portfolio diversity then creates an appearance of methodological breadth while leaving the relevant exclusion untouched. Section 9.8 therefore treated productive methodological redundancy as overlap among methods with partly independent failure modes rather than simple multiplicity.

Cross-method disagreement can reveal such exclusions. An ethnographic observation that does not fit an administrative category can indicate category loss. A historical sequence that cannot be represented in a static network can indicate temporal loss. A quantitative residual concentrated in one institutional boundary can indicate omitted relational structure. These findings should first be treated as diagnostic signals. The project can then determine whether the blind spot requires another method, another representation, a narrower claim, or a revised object.

Definition 9.119 (Method blind-spot register). A *method blind-spot register* records the dimensions of the research object that each method cannot adequately access or preserve, the reasons for the limitation, the findings potentially affected, and the complementary methods, representations, or scope restrictions used to address the resulting uncertainty.

The register should evolve during inquiry. A blind spot can become visible only after another method produces a conflicting finding. New data can reduce one limitation while creating another through changed categories or access conditions. Recording these changes makes methodological learning part of the project history.

Blind-spot analysis also disciplines AI-assisted synthesis. Automated systems can integrate large volumes of text or data while inheriting omissions from available records, benchmark categories, retrieval systems, or model training. Apparent synthesis can therefore reproduce common upstream absence. Chapter 9 will return to AI-assisted workflow in Section 254; the present point is that automated breadth should be assessed through the same provenance and blind-spot logic as other methods.

9.10.6 Irreducible Disagreement

Some cross-method disagreements remain after reasonable efforts at alignment, additional data collection, sensitivity analysis, alternative representation, and theoretical clarification. The role of this subsection is to treat such residual plurality as a legitimate project-level outcome. The objective is to distinguish preserved disagreement from unresolved methodological negligence and to specify how several interpretations can remain active without being flattened into a weak consensus statement.

Irreducible disagreement can arise from several sources. Historical evidence can permit more than one reconstruction because decisive traces were never produced or

preserved. Competing models can remain observationally compatible while implying different mechanisms. Participant standpoints can generate substantively different interpretations of the same institution. Normatively salient concepts can resist complete translation across communities. Different scales can disclose structures that cannot be compressed into one representation without consequential loss. In each case, additional technique may reduce uncertainty without guaranteeing unique closure.

The project should establish that reasonable diagnostic work has been performed. The object and scope should be aligned sufficiently for comparison; obvious measurement errors should be examined; relevant alternative representations should be considered; shared evidential dependencies should be identified; and feasible discriminating evidence should be sought. Preservation becomes appropriate when the remaining disagreement reflects genuine underdetermination, standpoint dependence, representation remainder, missing evidence, or competing but defensible inferential bridges.

Irreducible disagreement does not require symmetrical confidence. One interpretation can receive stronger current support while another remains plausible enough to preserve. The project can state the asymmetry while retaining the weaker interpretation because future evidence, category revision, or historical re-epistemization may alter the balance. This is consistent with the epistemic commitments developed in Chapter 5, where revisability depends on preserving the provenance, alternatives, and conditions under which a working conclusion was reached.

Definition 9.120 (Adjudicative plurality). *Adjudicative plurality* is a documented project state in which more than one interpretation remains epistemically admissible after reasonable cross-method comparison, with their relative support, unresolved differences, downstream consequences, and reopening conditions explicitly preserved.

Adjudicative plurality can be analytically productive. Competing interpretations can define alternative mechanism sets, suggest different future observations, or expose which categories are carrying unresolved theoretical commitments. The disagreement therefore becomes part of cumulative inquiry rather than a defect hidden during reporting.

The language used in the manuscript should reflect this state precisely. A project can report that the available evidence supports one interpretation more strongly while a second remains compatible with a subset of the evidence. It can report that two mechanisms are not presently distinguishable. It can report that findings are scale-dependent or standpoint-dependent. Such formulations preserve warranted uncertainty without dissolving substantive difference.

9.10.7 Revision after Conflict

Cross-method conflict becomes methodologically valuable when it can revise the research architecture. The role of this subsection is to specify how adjudicative findings propagate backward through the design chain developed earlier in Chapter 9. The objective is to avoid both local patching and indiscriminate redesign. Revision should target the smallest consequential component that explains the conflict and should

propagate to every dependent component whose interpretation changes as a result.

The architecture developed in Section 9.3 connected concept, object, representation, evidence, method, inference, and claim. A conflict detected at the claim level can therefore originate at several upstream points. A category can be too coarse. The object boundary can omit a consequential relation. A dataset can encode an obsolete institutional classification. A representation can erase temporal ordering. A method can rely on an assumption that fails in one subgroup. An inferential bridge can overstate what the evidence supports. A theoretical mechanism can be incomplete. Adjudication localizes the conflict so that revision can return to the relevant level.

Revision can also reach the research question. A project may begin by asking whether one mechanism explains an outcome and discover that the more adequate question concerns several mechanisms operating under different conditions. A presumed stable relation can become a historical transformation problem. An average-effect question can become a heterogeneity question. These changes should be recorded as theoretical development rather than hidden by rewriting the final question as if it had existed from the beginning.

Recursive and adaptive sequencing in Section 9.9 already established return paths for such changes. Cross-method adjudication supplies an important class of return conditions. Persistent contradiction, systematic divergence, unexpected asymmetry of evidential strength, or exposure of a shared blind spot can each justify reopening earlier choices. The revision should record the trigger, affected components, retained results, invalidated results, and new dependencies.

Definition 9.121 (Adjudication-triggered revision). *Adjudication-triggered revision is a documented change to the research question, object, boundary, data architecture, representation, method portfolio, sequence, inference, or theory that is motivated by a localized cross-method conflict and propagated through the components whose interpretation depends on the revised element.*

Revision should preserve continuity where possible. A change in one measurement definition does not automatically invalidate an entire historical reconstruction. A revised boundary need not erase interviews whose substantive interpretation remains stable. Conversely, a category change can require reprocessing several datasets and reopening earlier comparisons. Dependency tracking makes these consequences visible.

A project should also distinguish revision from post hoc rescue. Revision is epistemically productive when the reason for the change is documented, the revised architecture creates new tests or clarifies the inferential scope, and earlier incompatible states remain reconstructible. Repeated alteration solely to recover a preferred conclusion weakens the project because the decision process becomes outcome-dependent. Research governance in Section 255 will return to the institutional and procedural dimensions of such decisions.

Proposition 9.122 (Revision proportionality). *Cross-method conflict supports proportionate revision when the project can localize the source of incompatibility, identify which dependent components are affected, and preserve the provenance of both the pre-revision and post-revision research states.*

9.10.8 Preservation of Competing Interpretations

The final adjudicative task is preservation. Its role is to ensure that synthesis, weighting, or revision does not erase interpretations that remain relevant to the epistemic history of the project. The objective is to preserve enough information for later researchers to reconstruct why a finding was accepted, qualified, displaced, or retained as an alternative. This requirement connects cross-method adjudication to historical re-epistemization, cumulative research, and the open research programme developed later in Chapter 9.

Preservation should include more than the final prose description of a disagreement. The project should retain the competing claim formulations, evidence and source provenance, data and model versions where feasible, representations, analytical code or transformation history, method-specific assumptions, adjudicative reasoning, relative evidential weighting, unresolved uncertainties, and the conditions that would justify reopening the issue. If one interpretation is displaced after revision, the earlier state should remain recoverable rather than being silently overwritten.

Competing interpretations can also be preserved at different levels. Two interpretations may share the same observations while differing in mechanism. They may use different boundaries around the same object. They may disagree about category meaning while agreeing on measured patterns. They may offer different historical periodizations. Recording the locus of difference makes future comparison possible when new evidence or methods become available.

Preservation has particular importance in a generative framework because later transformations can alter the epistemic significance of earlier traces. New archives can open, institutional categories can be reinterpreted, computational reconstruction can become possible, or later events can reveal that an earlier divergence marked the beginning of a structural transition. A project designed only for present closure can lose this future epistemic option value.

A compact adjudication record can therefore accompany each consequential cross-method conflict. It should identify the focal claim, participating methods, outcome classification, aligned dimensions, evidential asymmetries, blind spots, selected working interpretation, preserved alternatives, revision consequences, and reopening conditions. Such records can later be aggregated into the historical re-epistemization plan developed in Section 253.

Definition 9.123 (Cross-method adjudication record). A *cross-method adjudication record* preserves the participating findings and methods, the dimensions on which they were aligned, the adjudicative state, evidential weighting, unresolved disagreements, revisions undertaken, working conclusion, preserved alternatives, provenance, and conditions for future re-evaluation.

Preservation also disciplines final synthesis. A coherent manuscript need not present every disagreement with equal prominence, yet its apparent coherence should remain reconstructible from the underlying evidential history. The project can state a working interpretation while preserving alternatives in appendices, repositories, versioned notes, supplementary models, or structured metadata when appropriate. The aim is to combine communicative clarity with epistemic reopen-

ability.

Cross-method adjudication therefore completes the transition from method plurality to integrated project reasoning. Convergent findings can strengthen specified claim components; divergent findings can differentiate the object; contradictory findings can localize architectural instability; unequal evidence can justify asymmetric weighting; blind spots can redirect the portfolio; irreducible disagreement can remain explicitly plural; and conflict can trigger proportionate revision while competing interpretations remain preserved. The next problem concerns the special relation between formal or computational models and the evidence used to construct, constrain, test, revise, or replace them. Section 249 develops that model–evidence dialogue.

9.11 Model–Evidence Dialogue

The preceding sections assembled the project-level architecture of Generative Relational research, organized its method portfolio, specified method sequencing, and developed procedures for cross-method adjudication. The role of the present section is to examine a more specific recursive relation within that architecture: the dialogue between formal or computational models and the evidence used to construct, constrain, confront, revise, compare, or replace them. Its objective is to distinguish several depths of revision—parameter, structural, categorical, methodological, and theoretical—so that a model–evidence discrepancy is diagnosed before it is repaired. The section proceeds from model formation and empirical confrontation through progressively deeper forms of revision, then considers replacement, multiple-model reasoning, and the residual indeterminacy that can remain after model selection. The method of argument is architectural and diagnostic. Models are treated as explicit representations with inferential roles, while evidence is treated according to its provenance, dependence, scope, and relation to the modeled object.

The dialogue considered here is broader than statistical fitting. A model can be algebraic, graphical, geometric, dynamical, agent-based, probabilistic, causal, field-theoretic, spacetime-based, historical-computational, or another explicit representation that supports disciplined inference. Its evidential interfaces can include measurements, archival sequences, relational traces, institutional records, interviews, comparative cases, intervention results, reconstructed events, or observations of intermediate mechanisms. Some models contain estimated parameters; others contain typed relations, ordering constraints, transition rules, symmetries, boundary conditions, or category systems that cannot be reduced to a vector of fitted coefficients. Model–evidence dialogue therefore concerns the full relation between a representation and the manifestations through which the target domain becomes epistemically accessible.

This broader formulation follows from the architecture already developed in Chapter 5 and Chapter 8. Manifestations can constrain several relational reconstructions without uniquely selecting one. Formal success does not by itself establish substantive correspondence. Simulation can establish what follows from encoded rules while remaining distinct from evidence that those rules operate in the target

system. Chapter 9 adds a project-design consequence: confrontation with evidence should be able to travel backward through the modeling architecture, revising the component at which the discrepancy is best localized rather than automatically changing the most convenient numerical quantity.

Definition 9.124 (Model–evidence dialogue). A *model–evidence dialogue* is the documented recursive process through which a research model is formed from theoretical, representational, and evidential commitments; confronted with evidence relevant to its claims; and retained, qualified, revised, pluralized, or replaced according to the location and consequence of the resulting correspondence or discrepancy.

Definition 9.124 makes the direction of influence explicitly bidirectional. Theory and prior evidence help form a model, but the model can also identify new observations, reveal non-identifiability, expose category ambiguity, generate discriminating implications, or show that available data cannot answer the original question. Evidence can constrain a model, while the model can reorganize what counts as relevant evidence. This reciprocity becomes epistemically productive when the transformations on both sides remain visible.

Table 9.2 summarizes the principal revision depths developed in this section. The ordering is analytical rather than mechanical. A project should not always begin with parameter revision and proceed downward row by row. The appropriate revision level depends on where the discrepancy is generated and on which components of the research architecture remain warranted.

The table also clarifies why revision depth is an inferential issue. A discrepancy between model output and observation does not carry its own diagnosis. The same deviation can result from an incorrect parameter, a missing relation, an unstable category, an unsuitable measurement procedure, a theoretical omission, or a mismatch between the modeled boundary and the empirical field. The research architecture therefore needs a disciplined route from discrepancy to revision.

9.11.1 Model Formation

Model formation is the stage at which a research project translates selected theoretical distinctions, object specifications, evidence, and methodological purposes into an explicit representational architecture. Its role in model–evidence dialogue is to make the initial commitments inspectable before confrontation begins. The objective is to distinguish what the model assumes, what it inherits from evidence, what it leaves open to estimation or calibration, what it represents only approximately, and what inferential work the model is expected to perform. The method is a structured translation from the research question and object architecture developed in Sections 9.2 and 9.3 into the representation and method architecture developed in Sections 9.7 and 9.8.

A model begins from a purpose. It may be intended to reconstruct relations, summarize structure, estimate an effect, represent a field, explore dynamical regimes, simulate a proposed mechanism, identify reachable trajectories, formalize a partial order, compare institutional designs, or generate counterfactual histories. These purposes impose different adequacy requirements. A descriptive network model can remain useful without representing the full generative process. A mechanism model

Table 9.2: Revision depths in model–evidence dialogue

Revision depth	Primary locus	Characteristic trigger	Typical project consequence
Parameter	Values within a retained model structure	Magnitude, timing, rate, threshold, or distribution differs while the structural grammar remains plausible	Re-estimate, recalibrate, widen ranges, or revise uncertainty
Structural	Relations among modeled components	Persistent pattern or sequence failure cannot be repaired credibly by parameter change alone	Add, remove, split, reorder, or reconnect mechanisms and state relations
Categorical	Variables, states, relation types, event classes, or object distinctions	Evidence shows that the model's categories merge consequentially different phenomena or impose unstable distinctions	Redefine categories and reprocess dependent data or representations
Methodological	Procedure linking evidence and model	Discrepancy arises from measurement, sampling, coding, identification, simulation, or validation procedure	Revise the method portfolio, sequence, or evidential interface
Theoretical	Explanatory commitments used to organize the model	Repeated discrepancies undermine the explanatory principle or scope assumed by the model family	Narrow, extend, recombine, or revise theory
Replacement	Model family or representational grammar	Another architecture explains consequential evidence with stronger correspondence and fewer unsupported repairs	Retire or demote the incumbent model while preserving its provenance
Pluralization	Relation among several admissible models	Evidence constrains the candidate set without uniquely selecting one representation	Maintain a documented multiple-model architecture
Residual selection uncertainty	Remaining model comparison problem	Relevant evidence, criteria, or translation relations remain insufficient for unique selection	Preserve alternatives, scope the conclusion, and define reopening conditions

requires greater attention to intermediate states and transition rules. A predictive model can perform well while remaining weak as a substantive explanation. An intervention model requires correspondingly stronger discipline about action variables, transport, and consequences. The project should therefore state the model's role before evaluating its success.

Formation also requires a separation between *structure* and *numerical specification*. The structure includes the variables or states admitted, relation types, admissible transitions, dependency relations, boundary assumptions, temporal ordering, scale, and other organizing constraints. Numerical specification includes parameter values, distributions, weights, rates, thresholds, or estimated functions inside that structure. This distinction prepares the later difference between parameter and structural revision.

Evidence can enter model formation at several points. Earlier qualitative or historical inquiry can define categories. Administrative records can establish institutional constraints. Preliminary measurement can determine plausible parameter ranges. Relational traces can inform network topology. Comparative cases can identify candidate mechanisms. Theory can constrain what relations are represented before any estimation occurs. Each of these uses should remain distinguishable because evidence used to form a model cannot later be treated automatically as independent

confirmation of the same component.

Definition 9.125 (Model-formation record). A *model-formation record* documents the model’s research purpose, target object, boundary, scale, categories, representation, structural assumptions, evidential inputs, free or estimated components, computational implementation where relevant, intended outputs, inferential role, known omissions, and planned confrontation criteria.

The model-formation record makes model construction compatible with the provenance discipline of Section 9.6. It also prevents a finalized model from concealing the sequence through which its structure was selected. A model that appears compact at publication can have emerged from discarded variables, category revisions, exploratory simulations, failed specifications, or historical reconstruction. Preserving this formation history allows later researchers to distinguish evidential learning from retrospective rationalization.

Formation should also identify the relation between abstraction and omission. Every model compresses. A network model can omit institutional meaning. A dynamical model can collapse actor heterogeneity into state variables. An agent-based model can represent institutional rules while omitting legal interpretation. A spacetime representation can preserve ordering and adjacency while abstracting from phenomenological meaning. These omissions can be acceptable when they are proportionate to the research purpose and when later inferences do not silently rely on what the model removed.

Proposition 9.126 (Formation transparency). *Model–evidence dialogue is more diagnostically informative when the project distinguishes evidence used to form the model, components fixed by theoretical or representational commitments, components estimated or calibrated from data, and evidence reserved for later confrontation.*

Proposition 9.126 does not require complete independence among these components. Historical and interpretive research often cannot partition evidence as cleanly as a controlled predictive exercise. The requirement is documentary: when evidence plays several roles, those dependencies should be recorded so later agreement is not mistaken for independent support.

9.11.2 Empirical Confrontation

Empirical confrontation brings the model into contact with evidence capable of constraining its represented relations, implications, trajectories, or outputs. Its role is to transform model evaluation from internal coherence into correspondence-sensitive inquiry. The objective is to compare the model with evidence at the dimensions relevant to its purpose while preserving the distinction between observational manifestations and the relational configuration inferred from them. The method is plural: confrontation can occur through measurements, sequences, mechanism traces, structural patterns, comparative variation, intervention outcomes, historical records, or other evidence appropriate to the claim.

Confrontation should be multidimensional where the model makes multidimensional claims. Endpoint agreement is informative for some purposes but weak for a model that purports to represent a generative pathway. A simulation can reproduce

an aggregate distribution while generating intermediate transitions absent from the historical record. A network model can fit observed edges while misrepresenting the institutional conditions under which those edges form. A causal model can estimate a stable average while hiding subgroup pathways that are central to the research question. The dimensions chosen for confrontation should therefore follow the model's inferential role.

A useful confrontation profile distinguishes at least the modeled implication, the relevant manifestation, the transformation connecting manifestation to evidence, the comparison rule, the expected uncertainty, and the consequence of discrepancy. Some comparisons can be numerical. Others are ordinal, structural, temporal, categorical, or interpretive. A partially ordered event model can be confronted with admissible sequence relations. A field model can be confronted with observed position-dependent differences. An institutional model can be confronted with rule application, enforcement, and practical accessibility. The absence of a universal metric does not prevent disciplined confrontation.

Definition 9.127 (Empirical confrontation profile). An *empirical confrontation profile* links a specified model implication to the evidence bearing on it, the observational or historical process through which that evidence became available, the comparison criterion, relevant uncertainty and dependence, the observed correspondence or discrepancy, and the range of model components that the result can legitimately constrain.

The final element in Definition 9.127 is crucial. A failed comparison constrains only the model–evidence relation actually tested. If the evidence is weakly informative about a mechanism, mismatch cannot by itself establish mechanism failure. If a model was constructed for qualitative regime exploration, a small numerical residual can be irrelevant. Conversely, apparently good fit can provide little support when the model was heavily calibrated to the same target or when many flexible specifications could reproduce it.

Confrontation should also include evidence that the model did not generate or select merely because it was convenient. Historical anomalies, deviant cases, missing predicted traces, boundary-sensitive observations, and observations from alternative standpoints can provide especially useful tests because they challenge the model where its representational commitments are exposed. Cross-method adjudication from Section 9.10 can enter here when different confrontation methods produce different verdicts about the same model component.

Caution 9.128 (Confrontation dependence). A close correspondence between model and evidence should not be interpreted as independent validation when the same evidence, labels, or transformation rules substantially determined the model component being evaluated. The dependence should be recorded and the resulting warrant scoped accordingly.

Empirical confrontation therefore creates a diagnostic state rather than a binary pass/fail result. Agreement can strengthen a specified component. Disagreement can localize a mismatch. Ambiguous confrontation can reveal that the evidence is insufficiently discriminating. The next task is to determine the depth at which revision should occur.

9.11.3 Parameter Revision

Parameter revision adjusts quantities, distributions, thresholds, rates, weights, or other free values while retaining the principal structural grammar of the model. Its role is to correct or update numerical specification when the evidence challenges magnitude or timing more strongly than model organization. The objective is to preserve an adequate structure while improving correspondence and uncertainty representation. The method includes estimation, calibration, posterior or interval updating where appropriate, sensitivity analysis, and comparison of revised parameter regions with the evidence that motivated the change.

Parameter revision is warranted when the model's categories, relations, and transition structure remain substantively defensible but particular values are weakly supported, historically changed, or empirically inconsistent. A diffusion model can retain its interaction structure while revising a transmission rate. An agent-based model can retain its behavioral rule while revising the distribution of resource endowments. A dynamical model can retain a state-space structure while revising a threshold or response coefficient. Such changes are relatively local because they do not alter what kinds of modeled components exist or how they are connected.

The apparent locality of parameter revision can be misleading when parameters absorb omitted structure. A single coefficient can compensate numerically for an unrepresented subgroup difference. A friction term can absorb institutional barriers that vary across fields. A transition probability can hide several distinct mechanisms. Parameter improvement should therefore be assessed against interpretability as well as fit. Persistent need for implausible parameter values, extreme tuning, instability across cases, or mutually incompatible calibrations can indicate that the discrepancy belongs at a deeper level.

Definition 9.129 (Parameter revision). *Parameter revision* is a documented change to the numerical or distributional specification of a model that preserves its principal categories and structural relations while updating values in response to evidence, changed conditions, or improved estimation.

Revision should also preserve the evidence dependence of the new values. Parameters estimated from one historical period may not transport into another when the generating institutions have changed. Parameters calibrated to one field may encode its particular constraints. A generative model can therefore require time-indexed, field-indexed, or regime-indexed parameters rather than one supposedly universal value. Such differentiation remains parameter revision only while the underlying structural interpretation remains stable.

A project should document pre-revision and post-revision parameter states, the evidence that motivated the update, the estimation or calibration procedure, uncertainty, and downstream outputs materially affected by the change. This record becomes especially important when later sections conduct sensitivity and robustness analysis.

Proposition 9.130 (Parameter-revision boundary). *Parameter revision remains an adequate response to model–evidence discrepancy only while the revised values retain defensible substantive interpretation and do not function primarily as compensating terms for unsupported categories, missing relations, or incorrect structural assump-*

tions.

Proposition 9.130 supplies a diagnostic boundary. Better numerical fit is not sufficient evidence that a parameter-level repair is epistemically appropriate.

9.11.4 Structural Revision

Structural revision changes the organization of the model itself. Its role is to respond when evidence challenges the relation among modeled components more strongly than their numerical values. The objective is to revise dependencies, transition rules, interaction topology, state structure, ordering constraints, feedback pathways, or other architectural features while preserving as much warranted content as possible. The method combines discrepancy localization with comparison of alternative structural specifications.

Structural discrepancy can appear in several forms. A model can reproduce outcome magnitude while failing on temporal order. A mechanism can generate a transition only after introducing a relation absent from the initial representation. A feedback process can be required to explain persistence. An institutional layer can alter the action set in ways that a homogeneous environment cannot represent. A network process can depend on higher-order relations rather than dyadic edges. These are structural problems because the model requires different connections or transition possibilities, not merely different values inside the existing architecture.

Structural revision should be selective. Adding components whenever the model fails can produce an architecture that follows the observed data without retaining explanatory discipline. The project should identify which discrepancy motivates each new component and which additional implications follow from the revision. A useful structural change creates discriminating consequences: it should alter expected trajectories, relations, or observations in ways that can be examined rather than merely increasing expressive flexibility.

Definition 9.131 (Structural revision). *Structural revision* is a documented modification of the relations, state architecture, transition rules, topology, feedback structure, ordering constraints, boundary conditions, or scale couplings through which a model organizes its represented components.

Structural revision can also simplify. A relation may prove unnecessary. Two transition pathways may collapse into one under the relevant empirical conditions. A highly detailed agent architecture can be replaced by a lower-dimensional dynamical description when the omitted heterogeneity does not affect the target question. Model improvement is therefore not synonymous with increasing complexity.

The project should distinguish revisions motivated by evidence from revisions motivated by computational convenience. Approximation can be legitimate, but its consequences for interpretation should remain explicit. A numerical solver can require discretization. A simulation can require a finite population. A graph representation can require relation typing. These implementation choices become structural only when they materially shape the substantive conclusions.

Proposition 9.132 (Discrepancy-localized structural revision). *A structural revision is epistemically stronger when the project can identify the discrepancy it is intended to*

address, show how the revised architecture changes relevant implications, and specify evidence capable of distinguishing the revised structure from plausible alternatives.

Structural revision often reveals that the difficulty lies even deeper, in the categories through which the model partitions the target domain. The next subsection addresses that possibility.

9.11.5 Category Revision

Category revision changes the distinctions through which the model defines states, entities, relation types, events, mechanisms, or outcomes. Its role is to address discrepancies produced by an inadequate partition of the empirical or relational domain. The objective is to preserve differences that the evidence shows to be generatively consequential and to remove distinctions that lack stable meaning for the local inquiry. The method combines conceptual analysis, historical reconstruction, interpretive evidence, measurement audit, and comparison of alternative codings or state definitions.

Categories can fail by excessive aggregation. A model can treat employment as one state while institutional form, security, dependence, and access to protections generate distinct trajectories. It can treat “trust” as a single variable while interpersonal reliance, institutional expectation, delegated authority, and constrained compliance have different relational structures. It can treat an organization as one actor when internal divisions determine the observed process. In each case, improved parameter estimation cannot recover distinctions that the category system erased before estimation began.

Categories can also fail through unnecessary fragmentation. Several labels can represent manifestations of the same relation under different administrative regimes. Historical sources can use changing names for a stable institutional function. Machine-assisted coding can create clusters whose boundaries are computationally reproducible but substantively weak. Category revision can therefore merge, split, rename, hierarchically organize, or historically index categories according to the research object’s generative structure.

Definition 9.133 (Category revision). *Category revision* is a documented change to the distinctions through which a model identifies or partitions its relevant entities, states, relations, events, mechanisms, or outcomes because evidence or conceptual analysis shows that the previous distinctions inadequately preserve the structure required by the research question.

Category revision has unusually wide downstream consequences. Data already coded under the former categories may require reprocessing. Earlier comparisons can become non-equivalent. Model parameters can change meaning. Historical continuity can require reassessment. Visualizations and tables can become misleading if old and new categories are silently mixed. The revision record should therefore identify which artifacts remain comparable and which need reconstruction.

The historical dimension is especially important. Category change can occur in the world as well as in the research project. A legal classification can be redefined, a market category can emerge, an institutional role can split, or a statistical office can

change its coding regime. The model should distinguish revision of the analyst's categories from historical transformation of the target categories themselves. In some projects, the latter is the substantive phenomenon being studied.

Proposition 9.134 (Category-priority diagnosis). *When a model–evidence discrepancy is generated by a distinction that merges generatively different phenomena or separates substantively equivalent ones, category revision should precede further parameter refinement because numerical adjustment cannot restore information already lost at the categorical interface.*

This proposition does not imply that categories must be maximally fine-grained. The appropriate resolution is question-relative. The point is that the category system should preserve the differences on which the intended inference depends.

9.11.6 Method Revision

Method revision changes the procedure through which evidence is generated, transformed, linked to the model, or used for confrontation. Its role is to address discrepancies that arise from the research process rather than primarily from the substantive model. The objective is to distinguish model inadequacy from measurement, sampling, coding, estimation, simulation, or validation inadequacy. The method is an audit of the evidential and computational interface connecting the target domain to the modeled representation.

A model can appear to fail because the data omit the relevant relation. A historical sequence can appear inconsistent because archival survival is selective. An estimated effect can vary because measurement changed across institutions. A simulation can appear unstable because the numerical implementation is defective. A machine-assisted classifier can distort a category boundary inherited from its training labels. A network model can appear structurally wrong because missingness is concentrated among peripheral actors. These cases require methodological diagnosis before substantive model revision.

Method revision can affect data collection, sampling, measurement, coding, pre-processing, estimation, identification strategy, computational implementation, calibration procedure, validation design, or comparison metric. It can also alter the method sequence. A project may discover that interpretive work should precede quantitative coding, that historical reconstruction is needed before formalization, or that a new field comparison is necessary to discriminate among model structures. Section 9.9 established the architecture for such sequencing changes.

Definition 9.135 (Method-revision trigger). A *method-revision trigger* is evidence that a consequential part of the observed model–evidence discrepancy is plausibly generated by the procedure used to observe, transform, estimate, compute, or validate the model rather than by the substantive model component alone.

Method revision should avoid becoming a route for protecting a preferred model from difficult evidence. The project should state why the methodological concern is independently plausible, how the revised procedure addresses it, and whether the original discrepancy survives under the new method. If every unfavorable result is attributed to measurement while favorable results are accepted without equivalent

scrutiny, the dialogue becomes asymmetrical and loses diagnostic value.

Cross-method adjudication is useful here because independent methods can reveal whether a discrepancy is method-specific. If archival reconstruction, interviews, and longitudinal measurement all indicate a transition that one model-based estimator fails to detect, the project has stronger reason to inspect that estimator's assumptions. If several methods sharing one data infrastructure fail together, the common source can become the methodological target.

Proposition 9.136 (Method–model separation). *A model should be substantively revised in response to discrepancy only after the project has examined whether a consequential portion of that discrepancy is generated by the evidential or computational procedure itself, to the extent that such examination is feasible for the research design.*

Proposition 9.136 is a diagnostic discipline rather than a requirement for exhaustive methodological testing. Some projects lack the resources for complete replication across procedures. The residual uncertainty should then be recorded rather than silently allocated to the model.

9.11.7 Theory Revision

Theory revision occurs when model–evidence dialogue challenges the explanatory commitments that organize one or more model structures. Its role is to connect local model failure to the wider conceptual architecture without allowing every discrepancy to become an immediate judgment on theory. The objective is to determine when accumulated evidence warrants narrowing, extending, recombining, or revising a theoretical account. The method traces the dependency from theoretical proposition to model structure, empirical implication, confrontation result, and alternative explanation.

Theory and model should remain analytically distinct. Several models can instantiate one theoretical idea. One model can incorporate propositions from several theories. A formal representation can be used heuristically without committing the project to a complete theory of the target domain. Theoretical revision is therefore warranted only when the challenged model component is sufficiently tied to a substantive theoretical commitment and when plausible alternative implementations do not resolve the discrepancy.

A theory can be revised by scope restriction. A mechanism can operate only under specified institutional conditions. A relational principle can hold at one scale but change after aggregation. A generative rule can depend on actor capacities that vary historically. These findings do not necessarily eliminate the theory; they can transform an unrestricted claim into a conditional one. Theory can also be extended by adding a previously omitted mechanism, differentiating a concept, or specifying interaction among processes.

More consequential revision occurs when the evidence repeatedly contradicts a central explanatory relation across reasonable model structures and methods. The project can then reconsider the conceptual architecture itself. A variable treated as an exogenous condition can become an endogenous historical outcome. A stable actor category can become a relationally generated position. A one-directional mecha-

nism can become a feedback system. A presumed equilibrium process can require a critical or path-dependent account. Such revisions alter the conceptual grammar through which future models are formed.

Definition 9.137 (Theory revision through model–evidence dialogue). *Theory revision through model–evidence dialogue* is a documented modification of the explanatory or conceptual commitments that organize a family of models when discrepancies, alternative representations, or new evidence materially weaken the warrant of those commitments within their stated domain.

Revision should preserve the distinction between empirical challenge and ontological conclusion. A formal model can fail without proving that its represented ontology is false; the representation may simply be unsuitable for the target question. Conversely, a successful model does not establish that its categories or mathematical structures are ultimate features of reality. The ontological suspension maintained throughout the book remains operative during theory revision.

Proposition 9.138 (Theory-revision threshold). *A local model discrepancy supports theory revision most strongly when the challenged model component is substantively entailed by the theoretical commitment, alternative reasonable implementations do not remove the discrepancy, and independent evidence or methods constrain the same explanatory relation.*

This threshold protects theory from both dogmatic insulation and premature abandonment. Theory remains revisable, while revision follows a documented path from evidence through model architecture to conceptual commitment.

9.11.8 Model Replacement

Model replacement occurs when revision within the current model architecture becomes less informative than adopting a substantially different representation or model family. Its role is to provide a disciplined exit from an incumbent model without erasing what that model previously contributed. The objective is to identify when accumulated repairs, category changes, structural exceptions, or empirical failures justify replacement and to preserve comparability between the outgoing and incoming architectures. The method compares inferential adequacy, evidential correspondence, transparency of assumptions, complexity, robustness, and retained explanatory content.

Replacement is stronger than structural revision. A structural revision changes relations within a recognizable modeling grammar. Replacement changes the grammar sufficiently that direct parameter or component correspondence can become partial. A dyadic network model can be replaced by a higher-order relational representation. A static equilibrium representation can be replaced by a dynamical trajectory model. A homogeneous-agent model can be replaced by an agent-based architecture. A single-scale model can be replaced by a multiscale field representation. These changes alter what the model is capable of expressing and therefore also alter the space of possible evidence-model comparisons.

Replacement should not be justified solely by better fit. A more flexible model family can improve empirical correspondence by absorbing noise or encoding more de-

degrees of freedom. The project should ask whether the new model preserves relevant domain semantics, exposes assumptions, generates discriminating implications, and improves the inferential task for which the model is used. Computational tractability and communicative clarity can also matter when several models have similar evidential adequacy.

Definition 9.139 (Model replacement). *Model replacement* is the documented substitution of one model architecture or model family by another because the incoming representation provides materially stronger adequacy for the research purpose across relevant evidential, structural, interpretive, and practical criteria than continued revision of the incumbent architecture.

The incumbent model should remain preserved where feasible. Earlier results can reveal why the replacement occurred, which phenomena motivated it, and which insights remain stable across representations. A displaced model can also remain useful for limited tasks even after losing its status as the project's principal model. Replacement therefore need not imply complete retirement.

A project can define explicit replacement triggers: repeated structural failure, unstable parameter compensation, persistent category mismatch, inability to represent a newly established mechanism, or a competing model that explains the same evidence while also accounting for observations outside the incumbent model's reach. These triggers should be specified in relation to the research purpose rather than through one universal metric.

Proposition 9.140 (Replacement with preservation). *Model replacement contributes to cumulative research when the project preserves the evidential reasons for replacement, the translation relations between old and new representations where available, the results that remain invariant, and the claims that lose or change their warrant.*

Replacement becomes less necessary when several models remain useful for different dimensions of the same object. The next subsection develops this multiple-model condition directly.

9.11.9 Multiple Models

Multiple-model reasoning retains several models within one research architecture when no single representation preserves all distinctions relevant to the question or when competing models remain empirically admissible. Its role is to prevent model selection from forcing premature representational unification. The objective is to distinguish complementary plurality from unresolved competition and to specify the translation, comparison, and provenance required for each. The method coordinates model roles rather than assuming that one model must dominate every inferential task.

Complementary plurality occurs when models represent different dimensions or scales. A narrative historical model can preserve sequence and category meaning. A graph model can reveal relational topology. A dynamical system can identify stability and transition structure. An agent-based simulation can explore local interaction rules. A spacetime representation can preserve partial ordering and composition of events. These models need not be reducible to one another to contribute to a shared

research project. Their coordination depends on identifying the objects, quantities, or events through which translations can be made and the information lost in those translations.

Competitive plurality occurs when several models offer different accounts of the same target claim. The evidence can favor one without uniquely excluding the others. Two mechanism structures can generate similar observed patterns. Several causal graphs can remain compatible with the available interventions. Different historical periodizations can support different model boundaries. Competitive plurality should be preserved when the evidence remains insufficiently discriminating.

Definition 9.141 (Multiple-model architecture). A *multiple-model architecture* is a project-level arrangement in which two or more explicit models are retained with documented roles, domains, translation relations, evidential supports, disagreements, dependencies, and conditions under which one model may supersede, constrain, or complement another.

The architecture should identify which findings are model-invariant and which are representation-dependent. An institutional discontinuity can appear across historical reconstruction, network change, and simulation. Its exact mechanism may differ across models. A policy conclusion can remain stable across several parameterizations but change under a different boundary model. Distinguishing invariant from model-dependent conclusions becomes an important input to the robustness architecture developed in Section 250 and Section 251.

Multiple models also help expose hidden assumptions. A relation treated as exogenous in one model can be generated endogenously in another. A homogeneous variable in one representation can split into several categories in another. A continuous field approximation can be compared with discrete agent dynamics. Such differences make modeling commitments visible even when the models produce similar aggregate outputs.

Proposition 9.142 (Plural-model retention). *A project should retain multiple models when their distinct representations provide consequentially different inferential access or when available evidence does not warrant unique selection, provided that their roles, incompatibilities, shared dependencies, and translation losses remain explicit.*

Plurality therefore does not mean that every model receives equal standing. Models can have different evidential support, domain scope, interpretability, and robustness. The architecture can weight or rank their use for specific tasks while still preserving alternatives whose exclusion would exceed the available warrant.

9.11.10 Scope and Residual Indeterminacy in Model Selection

The final problem concerns the scope of model selection and the indeterminacy that can remain after extensive confrontation and revision. Its role is to prevent a successful research workflow from being mistaken for a guarantee of unique model identification. The objective is to specify when selection is sufficiently warranted for the local research purpose, when several models remain admissible, and how residual uncertainty should propagate into later claims. The method combines comparison of evidential correspondence, representational adequacy, inferential purpose, robust-

ness, complexity, transparency, and domain scope while preserving the underdetermination established earlier in the book.

Model selection is purpose-relative. A model can be preferred for prediction while another is more suitable for mechanism interpretation. A compact model can support comparative estimation while a richer simulation better represents institutional heterogeneity. A historical reconstruction can be indispensable for category meaning even when it is not executable computationally. Asking which model is “best” without specifying the inferential task therefore collapses several criteria that can legitimately point in different directions.

Selection criteria can also conflict. Better fit can accompany weaker interpretability. Greater mechanism detail can reduce identifiability. A model with broad transportability can lose local historical specificity. A formal representation with elegant invariance can omit institutionally consequential distinctions. A flexible computational model can outperform simpler alternatives while making the source of its success difficult to interpret. The project should therefore state which criteria matter for the local claim and why.

Evidence can narrow the admissible model set without selecting a unique member. This condition is especially likely when manifestations are non-invertible, several mechanisms produce similar outcomes, categories remain partially contested, or evidence is sparse along the dimensions that distinguish models. Further data can reduce the set, but unique selection should not be assumed to follow automatically. Some distinctions can remain observationally inaccessible under the current epistemic regime.

Definition 9.143 (Residual model-selection indeterminacy). *Residual model-selection indeterminacy* is the documented condition in which more than one model remains adequately compatible with the research purpose and available evidence after reasonable confrontation, revision, robustness checks, and comparison, while the remaining differences cannot be resolved without additional evidence, altered assumptions, new methods, or a changed epistemic context.

Residual indeterminacy has direct consequences for reporting. Claims that are invariant across the remaining model set can be stated more strongly than claims that depend on one unresolved model choice. Model-contingent conclusions should identify that dependence. Where one model is adopted operationally for computational or communicative reasons, the manuscript should distinguish practical selection from evidential uniqueness.

The project should also preserve reopening conditions. New data can become available. An intervention can distinguish mechanisms. A historical archive can alter sequence reconstruction. A new representation can expose a previously hidden relation. Improved computation can make an alternative model tractable. Category change in the target domain can also make an earlier comparison obsolete. Model selection is therefore a temporally situated epistemic decision rather than a final elimination of alternatives.

Proposition 9.144 (Selection-scope discipline). *Model selection warrants stronger project-level closure when the selected model’s advantage is stable across the criteria relevant to the research purpose and when plausible alternatives are constrained by*

evidence that is sufficiently independent of the selection process; otherwise, residual model plurality should remain visible in the resulting claim.

The dialogue developed across this section can now be summarized as a recursive revision architecture. Model formation establishes a transparent representational contract. Empirical confrontation compares that contract with evidence at the dimensions relevant to its inferential purpose. Discrepancies can motivate parameter, structural, categorical, methodological, or theoretical revision according to their diagnosed locus. Accumulated failure can justify model replacement, while complementary or unresolved alternatives can be preserved through multiple-model architecture. Residual indeterminacy remains a legitimate endpoint when available evidence does not support unique selection. These operations convert modeling from a terminal analytic step into a revisable component of integrated research design.

The next project-level problem concerns sensitivity. Even a model that remains admissible after confrontation can generate materially different conclusions under plausible changes in parameters, boundaries, assumptions, categories, or methodological choices. Section 250 therefore turns from dialogue between model and evidence to the systematic analysis of how conclusions respond to such variation.

9.12 Sensitivity Analysis

Section 9.11 developed model–evidence dialogue as a recursive architecture in which discrepancies can motivate revision at several depths. The present section broadens that diagnostic logic from models to the research design as a whole. Its role is to examine how a specified inference changes when defensible elements of the project’s boundary, scale, parameters, data, historical window, representation, method, interpretation, or normative premises are varied. Its objective is to make dependence on research-design choices visible before such dependence is compressed into a final claim. The section proceeds through nine sensitivity dimensions and concludes by distinguishing sensitivity from the robustness architecture developed in Section 251. The method is controlled comparative perturbation: one or more consequential design components are varied within an explicitly justified range while the resulting changes in the target inference are recorded and interpreted.

Sensitivity analysis in this chapter is therefore broader than a numerical exercise. Some projects can vary parameters computationally and summarize the resulting response surface. Others need to compare alternative field boundaries, historical periodizations, coding schemes, archival source sets, representations, interpretive readings, or normative thresholds. The common structure is the same: a project identifies a consequential research choice, specifies a defensible alternative or range, reconstructs the target inference under that variation, and records which components remain stable, change gradually, cross a threshold, reverse ordering, become indeterminate, or require a different conceptualization.

The term *defensible* is important. Sensitivity analysis gains little from arbitrary perturbations that have no evidential, theoretical, historical, methodological, or practical justification. A boundary can be widened because plausible cross-boundary relations may matter. A historical window can be shifted because a transition date is

contested. A parameter can be varied across a range supported by evidence or model uncertainty. A coding interpretation can be changed because more than one reading remains reasonable. A normative threshold can be altered because the research question admits several legitimate evaluative standards. The perturbation set should be wide enough to test meaningful dependence while remaining related to the actual epistemic problem.

Definition 9.145 (Research-design sensitivity analysis). *Research-design sensitivity analysis* is the systematic reconstruction of a specified claim, estimate, model result, interpretation, or evaluative conclusion under two or more defensible variations in the research architecture in order to identify the location, direction, magnitude, threshold, interaction, or form of its dependence on those variations.

Definition 9.145 makes sensitivity claim-relative. A design change can leave one conclusion stable while altering another. Expanding a network boundary can preserve the identification of a central actor while changing the estimated concentration of power. Extending a historical window can preserve the existence of a transition while changing its inferred origin. Reclassifying an institutional category can leave aggregate totals nearly unchanged while transforming the interpretation of who bears a constraint. A project should therefore avoid describing an entire study as simply “sensitive” or “insensitive” when the dependence is localized to particular inferential components.

Sensitivity can also be substantive. High sensitivity does not automatically indicate poor research design. A near-critical process can genuinely respond strongly to small parameter changes. A relation can be constitutively boundary-dependent. A mechanism can operate at one scale and disappear under aggregation. A policy evaluation can change when the historical window crosses a regime transition because the underlying generative rule changed. In such cases, sensitivity reveals structure in the target domain. The methodological task is to distinguish sensitivity generated by the phenomenon from sensitivity generated mainly by arbitrary research choices, unstable measurement, or representational artifacts.

Table 9.3 summarizes the principal sensitivity dimensions used in this section. The dimensions can overlap. A change in historical window can alter the data available, the categories in use, the appropriate scale, and the model structure. A representation change can also require a different method. The table therefore identifies primary loci of variation rather than mutually exclusive compartments.

A complete sensitivity architecture also records interactions among dimensions. One-at-a-time variation can be useful for localization, but it can miss dependence that appears only when two choices change together. A wider field boundary can matter only at a finer scale. A parameter threshold can appear only under one historical regime. A data-source change can alter a category interpretation, which then changes the model structure. Joint sensitivity analysis should therefore be used when plausible dependencies among design dimensions are themselves part of the inferential problem.

Proposition 9.146 (Plausibility-bounded sensitivity). *Sensitivity analysis is most informative when the perturbation set is justified by live evidential, theoretical, methodological, historical, interpretive, or normative alternatives and when the target claim is*

Table 9.3: Principal dimensions of sensitivity analysis in integrated GR research design

Sensitivity dimension	Controlled variation	Primary diagnostic question	Typical output
Boundary	Inclusion and exclusion rules around the object or field	Which conclusions depend on omitted or newly included relations?	Boundary-stable and boundary-dependent claim components
Scale	Spatial, temporal, organizational, relational, or analytical resolution	Does the inferred structure change with aggregation, disaggregation, or level?	Scale profile and cross-scale discontinuities
Parameter	Plausible values, distributions, thresholds, or initial conditions	Which parameters materially govern the result and where are thresholds located?	Local, global, interaction, and threshold sensitivity
Data	Source set, sample, missingness treatment, measurement, transformation, or preprocessing	Which findings depend on particular evidential inputs or data-production choices?	Data-dependence profile and influential sources
Historical window	Start point, end point, duration, lag, or periodization	Does the conclusion depend on where historical observation begins and ends?	Window-stable components, regime breaks, and periodization dependence
Representation	Narrative, tabular, graph, geometric, field, algebraic, dynamical, or spacetime encoding	Which findings survive translation and which arise from a representational grammar?	Representation-invariant and representation-contingent components
Method	Plausible procedures for observation, estimation, reconstruction, modeling, or validation	Does the inference depend on one methodological route or shared assumption?	Method-dependence and failure-mode localization
Interpretation	Reasonable semantic, classificatory, documentary, or theoretical readings	Which conclusions require one contested interpretation?	Interpretive range, discriminating evidence, and unresolved plurality
Normative	Evaluative premises, thresholds, weights, standing, or priority rules	Which factual findings remain stable while evaluative conclusions change?	Normative-dependence profile and premise-specific conclusions

reconstructed under those alternatives without changing unrelated design components gratuitously.

Proposition 9.146 does not require that every alternative be equally probable or equally preferred. A weakly supported alternative can still be useful if it represents a consequential possibility that the current evidence cannot exclude. The project should record relative plausibility where it can, while avoiding the implication that sensitivity to an implausible extreme carries the same epistemic significance as sensitivity within the central evidential range.

9.12.1 Boundary Sensitivity

Boundary sensitivity concerns the dependence of an inference on the rule used to delimit the research object, case, field, relational neighborhood, or relevant environment. Its role is to test whether the analytical closure adopted earlier in the project excludes relations capable of materially altering the target conclusion. The objective is to distinguish conclusions that remain stable across defensible delimitations from conclusions whose content or warrant changes when the boundary moves. The method is comparative reconstruction under alternative inclusion and exclusion rules.

Chapter 5 established that boundaries are epistemic conditions rather than automatic ontological perimeters, and Section 9.5 translated that insight into field-

selection architecture. Boundary sensitivity operationalizes the resulting obligation. A firm can be delimited by legal incorporation, ownership, production relations, supply-chain dependence, financing, platform dependence, or ecological inputs. A market can be delimited geographically, institutionally, technologically, or through substitution relations. A research field can include formal participants while excluding informal actors who materially transmit information or bear consequences. The relevant sensitivity question is whether the target inference survives plausible changes among such delimitations.

Boundary variation can take several forms. *Expansion* adds actors, relations, events, institutions, or environments that plausibly participate in the process. *Contraction* restricts the object to a more tightly justified core. *Substitution* replaces one boundary criterion with another, such as legal membership with relational participation. *Layering* retains several overlapping boundaries simultaneously. Each operation asks a different question. Expansion tests omitted-relation dependence; contraction tests whether the inference is driven by peripheral elements; substitution tests whether the object changes under a different constitutive criterion; layering tests whether several valid boundaries reveal different dimensions of the same process.

A boundary-sensitive result is not automatically defective. If widening the field reveals that a locally stable arrangement depends on external finance, infrastructure, legal authority, or household reproduction, the sensitivity identifies a substantive constitutive relation. If a network centrality ranking changes sharply when informal ties are included, the result can show that formal records capture only one layer of authority. The methodological concern arises when a strong general claim is presented without acknowledging that it holds only under one delimitation.

Definition 9.147 (Boundary sensitivity profile). A *boundary sensitivity profile* records the defensible boundary specifications examined, the relations and observations added or removed under each specification, the claim components that remain stable, the components that change, and the substantive or methodological interpretation of those changes.

Boundary sensitivity should also preserve directionality. A conclusion can become stronger under expansion because omitted relations support the same mechanism. It can weaken because alternative pathways become visible. It can split because different subfields follow different dynamics. It can become non-identifiable because widening the object introduces several plausible explanations. These responses carry different implications and should not be reduced to a binary statement that the result is “robust” or “not robust.”

Boundary sensitivity can interact with ethical and practical scope. Expanding a field can reveal affected actors who were absent from the original evidence architecture. Their inclusion can alter both causal interpretation and the set of interests relevant to later application-dominant praxis. This does not require every research project to expand without limit. It requires the project to align the reach of its claim with the reach of the boundary it has tested.

Proposition 9.148 (Boundary-dependence disclosure). *When a consequential claim changes under a boundary specification that remains substantively defensible, the final*

claim should identify that boundary dependence and should avoid extending its scope beyond the delimitations for which the inference has been examined.

9.12.2 Scale Sensitivity

Scale sensitivity concerns the dependence of a claim on the level, resolution, or extent at which the target is represented and observed. Its role is to examine whether aggregation, disaggregation, temporal resolution, organizational level, spatial extent, or relational granularity changes the inferred structure or mechanism. The objective is to distinguish scale-specific processes from patterns that persist across scales and to identify the bridges required for cross-scale inference. The method is comparison across two or more justified scales with explicit attention to what is preserved and lost in each transformation.

Scale has several dimensions. Spatial scale can move from a workplace to a city, region, country, or transnational system. Organizational scale can move from individuals to teams, organizations, sectors, or institutional fields. Temporal scale can move from events to days, cycles, generations, or historical eras. Relational scale can move from dyadic ties to neighborhoods, communities, networks, or fields. Analytical resolution can move from individual events to aggregated states or coarse-grained trajectories. These dimensions can vary independently or together.

The multiscale methodology developed in Chapter 8 emphasized that cross-scale relations require explicit bridge mechanisms. Sensitivity analysis adds a project-design test: does the conclusion remain recognizable when the scale changes, and if it changes, can that change be explained by aggregation, emergent organization, altered boundary conditions, delayed propagation, or a transformation in the generative rule? A stable microlevel association can disappear at aggregate scale because opposing subgroups cancel. An aggregate pattern can arise even though no individual actor exhibits the same relation. A locally weak interaction can become consequential through repeated accumulation. A macroinstitutional rule can alter microbehavior through enforcement, interpretation, or resource constraints.

Scale sensitivity therefore requires more than recomputing the same statistic at different resolutions. The object itself can change. A relation that is meaningful among organizations may have no direct individual-level analogue. A field representation can preserve distributed effects that a dyadic graph fragments. A historical process observed over decades can contain several short-run regimes. The project should identify which transformations between scales preserve identity, which require new categories, and which introduce new inferential targets.

Definition 9.149 (Scale sensitivity profile). *A scale sensitivity profile records the scale dimensions examined, the transformation or aggregation rule connecting them, the claim components preserved across scales, the components that change, and the bridge evidence required to interpret cross-scale correspondence or divergence.*

Some scale sensitivity is expected in generative systems. Criticality, path dependence, field effects, network topology, and multilevel institutional organization can each produce different patterns at different scales. The project should therefore avoid treating scale dependence as a nuisance to be averaged away. A divergence can be the phenomenon of interest: aggregate access can improve while a subgroup

becomes more isolated; a national institution can remain stable while local practices transform; a global network can become more connected while neighborhood segregation increases.

Scale analysis should also test temporal granularity. A monthly series can conceal rapid oscillation. Event-level data can overemphasize transient fluctuation relative to slower structural change. Long-run averaging can make a regime transition appear as gradual drift. The appropriate granularity depends on the mechanism and the time constants of the processes involved. When several plausible temporal resolutions produce different interpretations, that dependence belongs in the sensitivity profile.

Proposition 9.150 (Cross-scale sensitivity discipline). *A change in a finding across scales supports a substantive cross-scale interpretation only when the project specifies the transformation connecting the scale-specific objects and examines whether the divergence can be attributed to aggregation, mediation, emergence, delayed propagation, or another evidenced bridge process.*

9.12.3 Parameter Sensitivity

Parameter sensitivity examines how a model result, estimated quantity, trajectory, classification, or decision-relevant conclusion changes across plausible values of explicitly parameterized components. Its role is to localize which numerical assumptions materially govern the result and to identify thresholds, interaction effects, and regions of qualitative change. The objective is to distinguish numerical uncertainty that produces only limited variation from parameter dependence capable of changing the substantive interpretation. The method can be analytic, computational, simulation-based, statistical, or comparative depending on the model architecture.

Parameters can represent rates, weights, thresholds, elasticities, transition probabilities, initial conditions, delays, capacities, costs, coupling strengths, priors, or other quantified elements. Their epistemic status can differ. Some are estimated directly from data. Some are calibrated from several sources. Some are chosen as scenario values. Some are heuristic parameters introduced to explore a formal mechanism. Sensitivity ranges should respect these differences. A tightly measured parameter can warrant a narrow evidential range, while a poorly observed structural quantity may require a wider range or a set of alternative distributions.

Parameter sensitivity can be *local* or *global*. Local analysis examines behavior near a focal specification and is useful for small uncertainty around well-supported values. Global analysis explores a wider admissible region and is more appropriate when interactions, thresholds, multiple regimes, or nonlinearity make local behavior unrepresentative. In dynamical and generative models, global sensitivity can be especially important because a small region can contain a bifurcation, attractor transition, or activation threshold beyond which the qualitative trajectory changes.

Sensitivity should also examine interactions. A parameter can appear unimportant when varied alone and become decisive when another parameter moves simultaneously. Institutional capacity and enforcement intensity can jointly determine whether a rule becomes enacted. Network connectivity and transmission probability can jointly determine propagation. Initial conditions and reinforcement strength can jointly determine path dependence. One-at-a-time variation is therefore a local-

ization device rather than a guarantee of complete sensitivity characterization.

Definition 9.151 (Parameter sensitivity envelope). A *parameter sensitivity envelope* is the evidentially, theoretically, or scenario-justified range or set of parameter specifications over which the project evaluates the stability, gradient, threshold behavior, interaction structure, or qualitative transformation of the target inference.

High parameter sensitivity can have at least three interpretations. It can indicate weak empirical identification, because the result changes substantially across values that the evidence cannot distinguish. It can indicate model fragility, because a conclusion depends on a narrow calibration. Or it can reveal a substantively sensitive regime in the target process. These interpretations require different responses. The first directs attention to evidence; the second to model architecture; the third to the generative phenomenon itself.

Parameter sensitivity should remain separate from structural sensitivity. If a model omits a consequential relation, varying existing coefficients more widely does not test that omission. Section 9.11 distinguished parameter revision from structural and categorical revision for the same reason. Sensitivity analysis should not allow a wide numerical range to stand in for uncertainty about the model grammar.

Caution 9.152 (Numerical sensitivity and structural uncertainty). A dense parameter sweep can characterize dependence within a specified model while leaving sensitivity to omitted relations, alternative categories, boundary choices, and model structures largely unexamined. Numerical coverage should therefore be interpreted within the architecture that generated the parameters.

9.12.4 Data Sensitivity

Data sensitivity concerns the dependence of a finding on the evidential inputs and data-production choices through which the target becomes observable. Its role is to test whether a conclusion is sustained across defensible changes in source inclusion, sampling, missingness treatment, measurement definitions, preprocessing, transformations, coding, or data integration. The objective is to identify influential evidential components and to distinguish substantive pattern from dependence on one fragile observational channel. The method is source-aware recomputation or reinterpretation with preserved provenance.

Section 9.6 treated data architecture as more than a collection of files. Data inherit selection mechanisms, institutional categories, recording practices, transformations, and access constraints. Sensitivity analysis should therefore vary the components that can plausibly alter the inference. A quantitative project can compare alternative missing-data treatments, samples, measurement definitions, outlier rules, transformations, or data sources. A historical project can compare conclusions with and without an archival collection whose survival is selective. A qualitative project can examine whether a theme depends disproportionately on one subgroup or coding decision. A relational project can assess how missing ties or observation thresholds affect topology.

Source removal can be informative when one source dominates a conclusion, but indiscriminate leave-one-out procedures are not always appropriate. Some evidence

is constitutive rather than redundant. Removing the only archive documenting a legal transition can destroy the research object rather than test sensitivity. The question is whether the alternative data specification remains meaningful for the claim. Sensitivity operations should preserve the distinction between testing dependence and intentionally discarding indispensable evidence.

Data sensitivity should also examine transformations between raw traces and analytical objects. Changes in inflation adjustment, geocoding, entity resolution, network thresholding, text preprocessing, category harmonization, or temporal aggregation can propagate into later results. A project can have stable raw evidence and unstable analytical data because a transformation rule is doing substantial inferential work. The provenance architecture should make these transformations available for sensitivity testing.

Definition 9.153 (Data-dependence profile). A *data-dependence profile* records the source sets, samples, measurement definitions, transformation rules, missingness treatments, coding choices, or preprocessing alternatives examined and identifies how each variation changes the target inference and its uncertainty.

Data sensitivity is particularly important when several sources share a common production process. Apparent stability across multiple datasets can provide limited reassurance if all inherit the same classification regime, institutional exclusion, sensor bias, or reporting incentive. Conversely, a disagreement between independently produced sources can reveal either measurement instability or genuine heterogeneity across manifestations. Cross-method adjudication in Section 9.10 provides a framework for diagnosing such conflicts.

Data sensitivity can also be historically generated. A category definition can change midway through a series. Archival preservation can be denser in one period. Digitization can increase observability after a technological transition. Administrative incentives can change reporting behavior. The next subsection treats temporal-window dependence directly, but the data architecture should record when time changes the meaning or availability of evidence itself.

Proposition 9.154 (Data sensitivity with provenance). A *data-sensitivity result* supports stronger inference when the alternative data specifications preserve source provenance and when the project distinguishes changes generated by evidential content from changes generated by transformations, missingness, classification, or access conditions.

9.12.5 Historical-Window Sensitivity

Historical-window sensitivity examines how a conclusion depends on the temporal interval used to reconstruct the target process. Its role is to test whether start dates, end dates, duration, lag assumptions, or periodization choices materially change the inferred trajectory, mechanism, continuity, or transformation. The objective is to prevent a convenient observation window from being mistaken for the natural history of the object. The method compares historically defensible temporal windows and records changes in sequence, baseline, regime identification, and generative interpretation.

Historical windows can influence inference through several mechanisms. A short window can treat an inherited condition as an initial state even though the condition was generated by earlier processes. A late start can omit formative events and make path dependence invisible. An early end can miss delayed effects or institutional adaptation. A long window can combine regimes whose categories, mechanisms, or measurement systems differ materially. A chosen baseline can make gradual recovery appear as rapid growth or make a cyclical pattern appear as secular decline.

Window sensitivity therefore concerns more than adding observations. The historical meaning of the object can change. Institutional categories can be redefined. Technologies can alter interaction structure. Legal jurisdictions can shift. A market can be reorganized. A relation that appears stable over one decade can cross a generative transition over three. The window should be treated as part of object construction rather than a neutral container around data.

Three operations are especially useful. *Expansion* tests whether earlier antecedents or later consequences alter the interpretation. *Contraction* tests whether a claim depends on distant periods whose comparability is weak. *Displacement* shifts a window of comparable duration to examine whether the inferred pattern is specific to one historical interval. Periodization sensitivity can additionally compare alternative transition dates or phase boundaries when the historical record supports more than one plausible segmentation.

Definition 9.155 (Historical-window sensitivity profile). A *historical-window sensitivity profile* records the temporal intervals and periodizations examined, the reasons each remains historically defensible, the changes they produce in sequence, baseline, mechanism, category meaning, or outcome interpretation, and the temporal conditions under which the target claim retains warrant.

Window sensitivity is central to generative attribution because causes and consequences can be delayed. An intervention can appear ineffective within a short horizon and consequential after institutional learning. A resource transfer can improve immediate output while depleting capacity later. A structural constraint can accumulate gradually before producing visible exclusion. A reform can produce a transient disturbance followed by a new stable regime. The observation horizon should therefore correspond to the temporal structure of the proposed mechanism where evidence permits.

Historical-window variation can also expose survivorship and hindsight effects. A sequence reconstructed from the endpoint can privilege events known to have mattered later while underrepresenting contemporaneous alternatives. Shifting the endpoint to earlier moments can help recover the option space visible to actors at the time. This does not eliminate hindsight, but it can reveal how later manifestations reorganize interpretation of earlier events.

Proposition 9.156 (Temporal-scope discipline). A *historical or generative claim* should state the temporal window over which its warrant has been examined, and material changes under defensible window expansion, contraction, displacement, or alternative periodization should be propagated into the claim's stated scope and mechanism interpretation.

9.12.6 Representation Sensitivity

Representation sensitivity concerns the dependence of an inference on the form through which the research object is encoded, visualized, formalized, or narrated. Its role is to test whether a conclusion survives translation among representations that preserve different aspects of the target. The objective is to distinguish findings that recur across representational grammars from findings produced largely by one encoding choice. The method compares alternative representations while documenting translation rules and losses.

Section 9.7 developed narrative, tabular, graph, geometric, field, algebraic, dynamical, spacetime, and multiple-representation architectures. Each form makes some relations easy to express and others difficult. A table preserves standardized comparison but can flatten sequence. A graph foregrounds relational topology while potentially suppressing rich institutional meaning. A state-space model can clarify dynamical structure while requiring prior choices about state variables. A narrative can preserve sequence, meaning, and ambiguity while making some comparisons less standardized. A spacetime representation can preserve partial ordering among events while introducing its own abstraction and translation requirements.

Representation sensitivity asks whether the target claim depends on those affordances. A centrality claim can change when a multiplex network replaces a single-edge graph. A historical turning point can appear differently when an event narrative is translated into discrete states. A field-like pattern can disappear when interactions are reduced to pairwise ties. A categorical table can suggest stable groups while a trajectory representation shows frequent transitions among them. These changes can identify representational loss rather than empirical contradiction.

Definition 9.157 (Representation sensitivity profile). A *representation sensitivity profile* records the alternative representations used for a common research target, the translation relations among them, the information each preserves or suppresses, and the claim components that remain invariant, change, or become unavailable under representation change.

Representation sensitivity should avoid treating all representations as interchangeable. Some transformations are only partially reversible. A rich interview record compressed into a categorical variable cannot be reconstructed from the variable alone. A continuous field reduced to discrete regions can lose gradients. A network aggregated into summary statistics can lose topology. The sensitivity analysis should therefore retain the richer source representation where feasible and record when comparison is asymmetric.

A result that survives several materially different representations can gain support because it is less likely to be an artifact of one encoding grammar. Yet cross-representational recurrence is not sufficient by itself. Several representations can inherit the same source bias or category error. The project should therefore combine representation sensitivity with data, method, and interpretation sensitivity rather than treating representational multiplicity as automatic validation.

Representation dependence can itself be theoretically informative. If a process appears coherent only in a higher-order relational representation, that result can indicate that dyadic decomposition loses consequential structure. If a trajectory becomes

interpretable only when temporal ordering is preserved, the sensitivity can identify sequence as constitutive. Such findings can motivate the structural or category revision described in Section 9.11.

Proposition 9.158 (Representation-dependence localization). *When a claim changes across defensible representations, the project should determine whether the change arises from information loss, altered object definition, different inferential affordances, or a substantive structure visible only at one representational resolution before assigning the difference to the target phenomenon.*

9.12.7 Method Sensitivity

Method sensitivity concerns the dependence of a claim on the procedure used to generate, reconstruct, estimate, model, compare, or validate evidence. Its role is to test whether the conclusion is tied to one methodological route or persists across alternative procedures capable of addressing the same inferential target. The objective is to localize method-specific dependence without presuming that all methods should converge. The method compares procedures that differ in consequential assumptions, evidential access, or failure modes while preserving alignment of the target claim.

The method portfolio in Section 9.8 already assigned distinct inferential roles to historical, interpretive, quantitative, formal, computational, and other methods. Method sensitivity builds on that architecture but asks a narrower question. Within a given role, would a plausible alternative method materially change the result? A causal estimate can be examined under several identification strategies. A network finding can be compared across community-detection or thresholding procedures. A qualitative coding result can be reconstructed under alternative coding frameworks. A historical mechanism can be examined through different source-selection or process-tracing strategies. A simulation result can be tested under different solution methods or initialization procedures.

Method sensitivity differs from cross-method adjudication. Adjudication governs findings that can arise from methods with different epistemic functions. Sensitivity analysis holds the target inference sufficiently fixed to examine dependence on alternative methodological routes. The distinction is important because divergence across methods can be expected when they access different dimensions of the object. Method sensitivity becomes diagnostic when the procedures are intended to support materially comparable claim components.

Definition 9.159 (Method sensitivity profile). *A method sensitivity profile records the alternative procedures used to address a specified inferential target, the consequential assumptions and failure modes that differ among them, and the extent to which the resulting claim changes across those procedures.*

Alternative methods should be selected for diagnostic leverage rather than prestige or numerical quantity. Two estimators with nearly identical assumptions provide limited information about assumption sensitivity. Two qualitative coders following the same category scheme can test implementation consistency without testing the scheme itself. Several simulations based on the same transition rules can test numerical stability while leaving structural uncertainty untouched. Productive method sensitivity therefore seeks variation in the assumption or operation actually under

question.

Method dependence can motivate several responses. A result can be scoped to the method under which it is supported. The project can collect discriminating evidence. A methodological assumption can be revised. The method portfolio can add a procedure with a different failure mode. The target claim can be decomposed so that one component is stable and another remains method-dependent. These responses preserve information that would be lost by simply averaging divergent outputs.

Proposition 9.160 (Method-sensitivity alignment). *Method sensitivity supports a meaningful comparison when the participating procedures address the same specified claim component and when their differences in assumptions, evidential access, or failure modes are explicit enough to interpret convergence or divergence.*

9.12.8 Interpretation Sensitivity

Interpretation sensitivity concerns the dependence of a conclusion on reasonable differences in how evidence, categories, texts, events, relations, or formal outputs are understood. Its role is to make semantic and inferential plurality visible where the same manifestation can support more than one reading. The objective is to identify which claim components require a contested interpretation, which interpretations remain compatible with the evidence, and what additional evidence could discriminate among them. The method is structured comparative interpretation with explicit preservation of interpretive premises.

Interpretation enters research at several stages. Documentary language can be ambiguous. Institutional categories can have formal and enacted meanings. Interview statements can depend on context, audience, and translation. Historical events can admit several periodizations or causal readings. Statistical patterns can support different substantive explanations. Formal outputs can be interpreted as mechanisms, approximations, analogies, or merely predictive structures. Sensitivity analysis should identify where these interpretive moves materially alter the claim.

Interpretation sensitivity does not imply that every reading deserves equal status. Evidence, context, linguistic competence, institutional knowledge, source provenance, theoretical coherence, and cross-source comparison can support some interpretations more strongly than others. The purpose is to preserve reasonable alternatives long enough to test their consequences and evidential requirements. Manufactured ambiguity created by ignoring decisive context should not be elevated to the same status as a genuinely live interpretive alternative.

Definition 9.161 (Interpretive alternative set). *An interpretive alternative set is a documented collection of substantively reasonable readings of a common evidential object or analytical result, together with the contextual support, assumptions, implications, and discriminating evidence associated with each reading.*

Interpretation sensitivity can be tested prospectively or retrospectively. Prospectively, a project can identify ambiguous concepts before analysis and record how different readings would alter coding or case comparison. Retrospectively, unexpected findings can reveal that an earlier interpretation was doing more work than anticipated. Reanalysis under an alternative reading can then determine whether the

conclusion changes or whether several interpretations lead to the same higher-level claim.

Interpretive dependence can also be scale- and standpoint-sensitive. A formal rule can be interpreted differently by administrators and affected persons. A market event can have different meanings for investors, workers, regulators, and households. These perspectives are not automatically reducible to one subjective average because their positions can confer different access to mechanisms and consequences. The project should distinguish perspective-dependent evidence from arbitrary preference and should record how position affects the interpretive claim.

When interpretation sensitivity persists after reasonable comparison, the appropriate output can be bounded plurality rather than forced selection. Section 9.10 developed adjudicative plurality for this purpose. The sensitivity result can identify which downstream conclusions are invariant across the live interpretations and which remain conditional on one reading.

Proposition 9.162 (Interpretive-dependence reporting). *When more than one substantively reasonable interpretation remains compatible with the evidence and those interpretations yield different consequential conclusions, the project should report the conditional dependence of those conclusions and preserve the evidence capable of re-opening the interpretation later.*

9.12.9 Normative Sensitivity

Normative sensitivity concerns the dependence of evaluative conclusions on explicit or implicit judgments about relevance, standing, value, harm, benefit, fairness, priority, acceptable risk, responsibility, or desirable outcomes. Its role in a research-dominant chapter is diagnostic rather than prescriptive. The objective is to distinguish empirical findings from the evaluative premises through which those findings become judgments about importance, improvement, justice, or acceptable tradeoffs, and to examine how those judgments change under defensible normative alternatives. The method is premise-explicit comparative evaluation.

Normative premises can enter long before a project reaches policy recommendation. The choice of outcome can privilege one conception of benefit. A threshold for meaningful change can embody a judgment about practical significance. A distributional analysis can decide whose gains and losses receive standing. A historical reconstruction can classify an institutional arrangement as inclusion, extraction, dependence, or repair partly through evaluative concepts. A risk analysis can prioritize expected aggregate effects or protection against severe minority harms. These choices can be legitimate, but their role should remain visible when they materially affect the conclusion.

Normative sensitivity should preserve the distinction between empirical disagreement and evaluative disagreement. Two analysts can agree on the distribution of outcomes while disagreeing about the weight assigned to equality, sufficiency, liberty, reciprocity, historical responsibility, ecological continuity, or future generations. Conversely, they can share a normative standard while disagreeing about the empirical consequences of an institution. Sensitivity analysis helps separate these layers so that a normative conflict is not presented as a factual dispute and an empirical

uncertainty is not hidden behind evaluative language.

Definition 9.163 (Normative sensitivity profile). A *normative sensitivity profile* records the evaluative premises, standing rules, thresholds, priority principles, or weighting choices relevant to a conclusion and identifies which empirical and evaluative claim components remain stable or change under substantively defensible alternatives.

The set of alternatives should be disciplined. Normative sensitivity does not require exhaustive comparison of every moral theory. The relevant alternatives arise from the research question, affected domains, institutional context, established debates, or explicit stakeholder positions. A project evaluating access can compare equality of access, sufficiency thresholds, priority to severely constrained groups, or capability-related interpretations when those alternatives materially bear on the question. A study of intergenerational effects can test how conclusions change when future consequences receive different legitimate forms of standing. The purpose is to expose dependence at the evaluative interface, not to simulate philosophical completeness.

Normative sensitivity can also reveal invariance. An institutional arrangement can appear problematic across several evaluative frameworks for different reasons. A finding can remain policy-relevant because all reasonable thresholds are crossed. Conversely, a recommendation can change sharply under small shifts in distributive weighting, revealing that the disagreement lies primarily in the normative premise rather than in the empirical model. Such localization can improve later application-dominant praxis because decision makers can see which parts of the disagreement require more evidence and which require explicit judgment.

GRE requires additional care because generativity itself should not be treated as an automatic normative good. A process can generate capacity for one actor while producing constraint for another. Increased option space can coexist with extraction, ecological degradation, or intensified asymmetry. A highly generative system can reproduce unjust conversion interfaces. Normative sensitivity should therefore avoid assigning positive value to generation merely because generation occurs. Later substantive and application chapters will develop the relevant economic and justice problems in greater depth.

Proposition 9.164 (Empirical–normative separation with interaction). A *normative sensitivity analysis* should distinguish changes generated by empirical assumptions from changes generated by evaluative premises while preserving their interaction when empirical categories, measured consequences, or institutional meanings themselves depend on normative concepts.

The interaction clause is necessary because a perfectly clean separation is not always available. Categories such as deprivation, exploitation, vulnerability, or reasonable access can contain both descriptive and evaluative elements. The appropriate response is to decompose them as far as the inquiry permits, state the remaining entanglement, and test whether alternative operationalizations change the conclusion.

Across all nine dimensions, sensitivity analysis functions as an architecture of disciplined perturbation. The project identifies a live alternative, changes a consequential component, reconstructs the relevant claim, and records both the response and

its interpretation. The resulting sensitivity profile should identify the perturbation domain, the target claim component, the direction and form of change, interactions with other dimensions, and the evidential or substantive explanation proposed for the dependence. This profile becomes an input to model revision, cross-method adjudication, uncertainty reporting, and later research decisions.

The several profiles should also be integrated at project level. Boundary, scale, parameter, data, historical-window, representation, method, interpretation, and normative sensitivity can be tested separately for diagnostic clarity, yet consequential findings can depend on their interaction. A change in boundary can expose a new scale relation; the new relation can require a different representation; the representation can alter the available method; and the resulting evidence can reopen an interpretation. Recording only the final changed result would conceal the dependency chain. Integrated sensitivity analysis therefore preserves both the perturbation and the path through which it reaches the target claim.

Definition 9.165 (Integrated sensitivity record). An *integrated sensitivity record* preserves the target claim, the design dimensions varied, the justified perturbation set, the sequence or combination of variations, the resulting changes in the claim, interactions among dimensions, the interpretation of those changes, untested dependencies, and any revision or scoping decision triggered by the analysis.

The record in Definition 9.165 helps separate two sources of observed sensitivity. *Epistemic sensitivity* arises primarily because available evidence, categories, methods, representations, or interpretations do not yet constrain the inference tightly. *Substantive sensitivity* arises when the target process itself changes materially across a small but meaningful change in conditions. The distinction is analytical rather than absolute. A project can initially observe sensitivity through a model and later determine that part of it comes from weak parameter identification while another part reflects a genuine threshold in the process. Preserving the diagnostic history allows this interpretation to be revised.

The absence of observed sensitivity should also be scoped carefully. Stability across a narrow set of perturbations does not establish general insensitivity. Several tested specifications can share one omitted relation, one data-production system, one category scheme, or one interpretive assumption. A project should therefore record which dimensions were varied, which were held fixed, why the perturbation range was selected, and which untested alternatives remain capable of changing the inference. This negative information becomes important when robustness is assessed in the next section.

Proposition 9.166 (Sensitivity-scope discipline). A *sensitivity result supports a claim about stability or dependence only within the design dimensions and perturbation domain actually examined; untested common assumptions and interactions should remain outside that claim unless independently constrained.*

Sensitivity remains distinct from robustness. A claim can be sensitive in one dimension yet stable within a justified domain, or appear insensitive across tested variations while sharing an untested assumption. Some sensitivity is substantively expected near thresholds, across scales, or during historical transitions. Section 251 develops the corresponding robustness architecture.

9.13 Robustness Architecture

Section 9.12 developed sensitivity analysis as a disciplined mapping of how research conclusions change under defensible perturbations in boundary, scale, parameters, data, historical window, representation, method, interpretation, and normative premises. The present section converts that map into a project-level architecture for evaluating stability. Its role is to specify what kinds of persistence, invariance, qualified transfer, and coherent translation can strengthen a research claim without turning robustness into a binary certification. Its objective is to coordinate evidential, relational, historical, generative, cross-method, cross-case, and cross-scale robustness within one documented design. The section proceeds through these seven dimensions and closes by specifying the scope conditions of robustness. The method is claim-relative comparison: each robustness judgment identifies a target inference, a justified contrast class, the dimensions allowed to vary, the components held fixed, the form of stability observed, and the residual dependencies that remain.

Robustness enters the book at several analytical levels. Earlier relational methodology examined validation and the stability of relational claims. Generative methodology then examined the stability of generative claims across alternative mechanisms, boundaries, scales, historical windows, formalizations, parameters, model architectures, and methods. Chapter 9 adds a further level. An integrated project can contain several claims, several evidence streams, several representations, and several methods whose robustness properties differ. One component can remain stable across datasets while another depends strongly on periodization. A mechanism can remain plausible across methods while its estimated magnitude varies across scales. A normative conclusion can be stable across several empirical reconstructions while remaining sensitive to the evaluative threshold used. Project-level robustness therefore requires an architecture capable of preserving these differentiated patterns.

The appropriate unit is a *robustness profile* rather than a robustness score. A scalar score would compress heterogeneous information whose meaning depends on the dimension being varied. Stability across archival source sets differs analytically from stability across model architectures. Cross-case transfer differs from cross-scale coherence. Agreement among methods that share one dataset differs from agreement among methods with independent evidential pathways. A project should retain these distinctions because each dimension supports a different type of warrant and points toward a different form of revision when stability fails.

Definition 9.167 (Project robustness architecture). A *project robustness architecture* is the documented organization of claim-relative robustness assessments across relevant evidential, relational, historical, generative, methodological, case, and scale contrasts, together with the provenance, dependence structure, scope conditions, and unresolved sensitivities needed to interpret the observed stability.

Definition 9.167 makes robustness relational to a comparison design. A conclusion cannot be described meaningfully as robust without specifying what has been varied and which conclusion is under evaluation. A finding can be robust to parameter uncertainty and fragile to historical periodization. A relation can be robust to missing observations and fragile to field-boundary choices. A mechanism can be robust across methods and cases while its timing changes substantially across scales. The

Table 9.4: Dimensions of project-level robustness in integrated GR research design

Robustness dimension	Principal contrast	Robustness-relevant stability	Residual dependence to report
Evidential	Source sets, measurements, missingness treatments, provenance assumptions, or evidential exclusions	Support for the specified claim remains adequate across justified evidential variations	Dependence on particular sources, measurements, or shared provenance
Relational	Boundary rules, tie definitions, actor classifications, missing relations, or alternative relational reconstructions	Core relational properties or qualified relational conclusions persist across defensible reconstructions	Boundary-sensitive ties, coding dependence, hidden relations, and relation-specific uncertainty
Historical	Start and end points, periodizations, lag structures, sequence reconstructions, or historical source configurations	Historically scoped claim survives plausible temporal reconstruction or changes in a structured way across regimes	Regime dependence, path dependence, timing uncertainty, and historically specific conditions
Generative	Mechanisms, enabling conditions, initial configurations, transition rules, feedback structures, or counterfactual pathways	Mechanism class, generative conditions, trajectory constraints, or transformation pattern remains supported	Equifinality, mechanism substitution, threshold dependence, and unresolved causal pathways
Cross-method	Methods with differentiated assumptions, representations, evidence access, and failure modes	Compatible warrant emerges through sufficiently independent methodological pathways	Shared assumptions, shared data, translation loss, and method-specific blind spots
Cross-case	Cases selected for typical, critical, deviant, boundary, comparative, negative, or generative roles	Claim transfers within stated scope or exhibits a reproducible pattern of structured variation	Case-specific conditions, selection logic, contextual translation, and transfer limits
Cross-scale	Spatial, temporal, organizational, relational, or analytical scales and their bridge rules	Claim remains coherent across scales or transforms according to an explicit and supported scale relation	Aggregation loss, emergent properties, scale-specific mechanisms, and bridge uncertainty

robustness claim should therefore identify the contrast class explicitly.

This requirement also links robustness to sensitivity. Sensitivity analysis describes the response of an inference to variation. Robustness assessment interprets that response relative to the inferential purpose. A modest quantitative change can leave a qualitative claim stable. A small numerical change can cross a substantively important threshold. A change in vocabulary can preserve relational structure. A stable endpoint can conceal a mechanism reversal. The robustness architecture therefore evaluates the structure of dependence revealed by sensitivity analysis instead of equating numerical similarity with stability.

Table 9.4 summarizes the seven dimensions developed below. The table identifies the principal contrast, the form of stability that can support robustness, the residual dependence that should remain visible, and a typical implication for claim scope. These dimensions can interact. A cross-case comparison can involve historical-window variation; a cross-scale analysis can require a representation change; cross-method robustness can depend on whether evidence streams are genuinely differentiated. Integrated analysis should preserve such interactions rather than treating the rows as isolated tests.

The project-level architecture should record several types of stability separately. *Exact stability* concerns a conclusion that remains effectively unchanged within the relevant contrast class. *Directional stability* concerns persistence of sign, ordering, or qualitative direction while magnitude changes. *Structural stability* concerns per-

sistence of relational or generative organization despite variation in numerical details. *Conditional stability* concerns a conclusion that remains stable within an explicitly identified regime or scope. *Transformational coherence* concerns cases in which a claim changes across contexts or scales according to a consistent translation rule. Each form can be epistemically useful. Requiring exact invariance everywhere would discard many historically and relationally meaningful forms of robustness.

Proposition 9.168 (Claim-relative robustness specification). *A robustness judgment gains interpretive value when it specifies the target claim, the justified contrast class, the relevant form of stability, and the residual dependence that remains after comparison.*

Proposition 9.168 prevents the term *robust* from becoming a free-standing commendation. Robustness is informative because it identifies which components of a conclusion survive which relevant alternatives. The remainder of the section develops this architecture dimension by dimension.

9.13.1 Evidential Robustness

Evidential robustness concerns the stability of support for a specified claim under defensible variation in the evidence architecture. Its role is to determine whether a conclusion depends disproportionately on one source, one measurement construction, one preprocessing choice, one document class, one witness group, one dataset, or one provenance chain. Its objective is to distinguish support that persists across differentiated evidential configurations from support that is concentrated in a narrow evidential pathway. The analysis varies evidence composition or evidential assumptions while preserving the target claim and recording which parts of its warrant remain adequate.

Evidence quantity alone provides a weak basis for robustness. Ten sources derived from the same administrative record can provide less independent constraint than three sources generated through distinct institutional processes. Several interviews can reproduce a common organizational narrative. Multiple databases can inherit the same upstream coding practice. A historical archive can preserve one class of actors disproportionately. Computationally distinct estimators can operate on the same measurement structure. Evidential robustness therefore depends on provenance and dependence as well as apparent replication.

Definition 9.169 (Evidential robustness profile). *An evidential robustness profile records how the warrant for a specified claim changes under defensible variation in evidence sources, source combinations, measurement constructions, missingness treatments, inclusion rules, provenance assumptions, or evidential exclusions.*

Several tests can contribute to this profile. A project can remove an influential dataset and reconstruct the inference. It can compare archival and contemporary records. It can vary measurement definitions. It can separate evidence produced by different institutions. It can test alternative treatments of missing observations. It can distinguish direct traces from model-derived or interpretation-dependent evidence. It can re-estimate a claim after excluding sources whose provenance is uncertain. Qualitative inquiry can perform analogous tests by comparing interpretations across source genres, positionalities, temporal layers, or documentary chains.

The purpose of such variation is diagnostic. If the conclusion disappears when one disputed record is removed, the project has identified a concentration of evidential dependence. If the conclusion persists across several source configurations while its magnitude changes, the qualitative core can be comparatively robust and the numerical component comparatively sensitive. If two independent source families support different parts of the claim, robustness can attach to the decomposed components rather than to the claim as an undifferentiated whole.

Evidential robustness should also distinguish *support stability* from *data stability*. The same dataset can produce stable numerical estimates across preprocessing choices while remaining weakly connected to the construct of interest. Conversely, several imperfect source types can support a conclusion through complementary traces. The project should evaluate whether the evidence continues to warrant the inference, not merely whether a computed statistic remains similar.

Provenance makes this assessment cumulative. Section 9.6 treated data architecture as a structured organization of sources and transformations. Robustness analysis can reuse that provenance structure to identify shared ancestry among evidence streams. If two apparently independent datasets derive from the same administrative classification, their agreement has a different evidential meaning from agreement between independent institutional records. A provenance graph can therefore reveal hidden dependence among robustness checks.

Proposition 9.170 (Provenance-aware evidential robustness). *Evidential convergence provides stronger robustness support when the contributing evidence streams have sufficiently differentiated provenance, production processes, or error structures to constrain the target claim through partially independent pathways.*

Proposition 9.170 does not require statistical independence in every project. Historical and qualitative evidence often have more complex dependence structures. The relevant requirement is that the project identify the dependence rather than count each source as a separate confirmation. Shared dependence can still be informative, especially when the shared production process is itself part of the object of inquiry.

Evidential fragility can guide new collection. A claim dependent on one historical interval suggests a search for additional records around that interval. A relation inferred from one actor group suggests purposive collection from positions likely to reveal missing ties. A model conclusion driven by one poorly measured variable suggests better measurement or a wider sensitivity range. Robustness architecture therefore converts evidential concentration into a prioritized research task.

The evidential profile should finally state what remains stable and at what strength. A project can report that the existence of a relation is stable across source sets while its magnitude remains uncertain; that the direction of a historical transition is stable while its date depends on one archive; or that a mechanism trace persists across documentary and interview evidence while its prevalence is weakly identified. Such decomposed reporting connects robustness directly to claim calibration.

9.13.2 Relational Robustness

Relational robustness concerns the stability of relational conclusions under defensible changes in how relations, actors, positions, fields, and boundaries are reconstructed. Its role is especially important in GR because the object of inquiry can change when relational boundaries or classifications change. The objective is to determine which relational properties persist across alternative reconstructions and which depend on a particular representation of the field. The analysis varies tie definitions, inclusion rules, actor classifications, missing-relation assumptions, directionality, weighting, or field boundaries while preserving the substantive question.

A relational claim can concern existence, direction, strength, reciprocity, mediation, centrality, closure, brokerage, dependence, hierarchy, clustering, field position, or another structural property. These components can have different robustness profiles. A connection between two organizations can be stable across datasets while its direction remains disputed. A brokerage position can persist across moderate boundary changes while the actor's numerical centrality shifts. A community structure can remain recognizable across several tie thresholds while membership at the boundary changes. Relational robustness therefore benefits from claim decomposition.

Definition 9.171 (Relational robustness profile). A *relational robustness profile* records which specified relational properties remain supported, transform coherently, or become indeterminate across defensible alternative reconstructions of actors, relations, field boundaries, directionality, weighting, missing ties, or relational representation.

Relational robustness is closely connected to boundary sensitivity developed in Section 9.12. The difference is evaluative. Boundary sensitivity maps what changes when inclusion rules change. Relational robustness asks whether the target relational inference retains enough stability across the justified boundary range to support a claim at a specified scope. A project can therefore report a stable internal structure within a field while qualifying claims about external dependence because those claims change when neighboring organizations are included.

Missing relations require particular attention. Relational data frequently contain asymmetrical observability. Formal contracts can be documented while informal influence remains partially hidden. Digital traces can record interaction frequency while omitting interpretive meaning. Survey nominations can reveal perceived ties while missing relations respondents hesitate to disclose. Robustness analysis can compare several plausible reconstructions of missing or uncertain ties and examine whether the focal structural conclusion survives.

Actor identity can also be relationally unstable. Organizations merge, coalitions change membership, departments acquire new functions, informal groups become formal institutions, and categories used by researchers can combine actors who occupy distinct positions. Alternative actor classifications can therefore alter the relational object itself. Robustness should record whether the conclusion survives these classifications or whether the research question requires a historically specific actor ontology.

Representation matters as well. A network graph, field description, matrix, narrative sequence, and geometric embedding can foreground different relational fea-

tures. Relational robustness does not require the representations to look identical. A stronger criterion asks whether the substantive relational structure relevant to the claim can be translated across representations without losing the property under evaluation. Translation failure can identify representation-specific conclusions.

Proposition 9.172 (Relational stability with reconstruction disclosure). *A relational claim is strengthened when its focal structural property remains supported across defensible relational reconstructions and when the relations, boundaries, or classifications responsible for residual variation are explicitly identified.*

Proposition 9.172 makes relational robustness compatible with heterogeneous fields. A claim need not survive arbitrary deletion or addition of ties. The contrast set should reflect plausible uncertainty, contested boundaries, or alternative representations. Robustness beyond that set has little interpretive value unless a broader transfer claim is being made.

Relational fragility can itself be substantively important. A brokerage position that disappears when one neighboring institution is included can indicate dependence on a narrow field boundary. A coalition whose coherence collapses when one weak tie is removed can reveal structural vulnerability. A power relation that changes direction across contexts can indicate conditional authority. The robustness architecture should preserve these patterns as properties of the relational field when the variation corresponds to plausible changes in the field rather than merely to arbitrary analytical perturbation.

9.13.3 Historical Robustness

Historical robustness concerns the stability of historically scoped claims across defensible variations in temporal boundaries, periodization, sequence reconstruction, lag assumptions, and source configuration. Its role is to prevent a research project from treating one selected historical window as a neutral container. Its objective is to determine whether the claim survives plausible reconstructions of the relevant past, changes in a structured manner across regimes, or depends on a narrow temporal framing. The analysis therefore combines the historical-window sensitivity of Section 9.12 with explicit evaluation of which historical components retain warrant.

A historical claim can concern origin, timing, sequence, persistence, path dependence, critical juncture, institutional sedimentation, transformation, recurrence, or delayed effect. These claims require different robustness standards. A transition can be robustly identified even when its precise start date is uncertain. A sequence relation can remain stable while the duration of each stage changes. A claim about persistence can fail when the observation window is lengthened. A mechanism can appear stable within one institutional regime and change after a rule transformation. Robustness should therefore attach to the specific historical content of the claim.

Definition 9.173 (Historical robustness profile). *A historical robustness profile records the stability and structured variation of a historically scoped claim across defensible periodizations, temporal boundaries, lag structures, sequence reconstructions, regime classifications, and historical evidence configurations.*

Historical robustness differs from ahistorical generalization. A finding can be

highly robust within a particular institutional regime and inapplicable after the generative rules change. Such scope restriction can represent strong historical knowledge. A project should therefore avoid treating cross-period invariance as the only desirable outcome. Stable regime dependence, reproducible phase-specific behavior, or coherent transformation across periods can also support robust historical interpretation.

Starting points deserve special scrutiny. Beginning an analysis after a formative transition can make inherited relations appear fixed or exogenous. Beginning substantially earlier can combine distinct regimes and obscure the mechanism relevant to the focal period. Robustness analysis can compare alternative starting points motivated by historical arguments and examine which conclusions depend on the chosen temporal boundary. A similar logic applies to end points, especially where delayed effects, reversals, or institutional adaptation occur.

Periodization introduces conceptual dependence. Labels such as “pre-reform,” “transition,” and “post-reform” can organize evidence while also imposing a temporal grammar. Alternative periodizations can reveal whether an inferred turning point reflects the historical process or the categories used to divide it. The project can compare event-based, institutional, economic, political, technological, or actor-centered periodizations when more than one is defensible.

Sequence reconstruction creates another robustness problem. Historical records can underdetermine the ordering of closely spaced events, informal decisions, or latent changes. Several plausible sequences can be reconstructed. If the same limited mechanism claim survives all of them, that component gains robustness. If one ordering is necessary for the proposed mechanism, the uncertainty should be localized to the sequence and the evidence needed to discriminate among alternatives should be identified.

Historical robustness also includes source survival. Archives reflect institutions, preservation practices, destruction, classification, and unequal record-making power. A conclusion stable across several archives can still share a common preservation bias. Robustness analysis should therefore combine source comparison with an account of whose actions and interpretations were more likely to be recorded. A stable documentary pattern can reveal a stable administrative perspective rather than the complete relational history.

Proposition 9.174 (Historically scoped robustness). *Historical robustness is strongest when the target claim remains warranted across plausible temporal reconstructions or changes according to an explicitly supported regime structure, while the historical conditions limiting transfer are preserved as part of the claim.*

This proposition treats historical specificity as analytical information. A process that operates only before a regulatory transformation can still be robustly understood. A relation that persists across several institutional periods supports a broader claim. A mechanism that changes after a threshold can support a robust account of the transition itself. Historical robustness therefore concerns disciplined stability and disciplined variation across time.

The project-level record should preserve counter-histories as well. Alternative interpretations that remain plausible after adjudication can be retained with the ev-

idence that supports them. Later archival discovery or category revision can then reopen the historical inference without reconstructing the entire research path from memory. This anticipates the historical re-epistemization architecture developed in Section 253.

9.13.4 Generative Robustness

Generative robustness concerns the stability of claims about how change is produced. Its role is to evaluate whether a proposed generative account continues to explain or constrain the observed process when plausible mechanisms, enabling conditions, initial configurations, transition rules, feedback structures, and counterfactual pathways are varied. Its objective is to distinguish endpoint stability from stability of the generative organization that produces the endpoint. The analysis therefore treats mechanism, conditions, trajectory, rule structure, and transformation as separable components of robustness.

A project can obtain the same observed outcome from several generative pathways. Similar aggregate growth can arise through diffusion, redistribution, institutional change, network expansion, compositional change, or measurement shifts. Similar institutional forms can emerge from different historical sequences. Similar levels of trust can be sustained by different relational configurations. Outcome robustness therefore provides limited information about generative robustness unless the mechanisms and pathway constraints are also examined.

Definition 9.175 (Generative robustness profile). A *generative robustness profile* records which components of a generative claim—including mechanism class, enabling conditions, transition structure, feedback, trajectory constraints, rule transformation, and outcome pattern—remain supported or transform coherently across defensible alternative generative accounts.

This profile can contain several levels of stability. The exact mechanism can remain stable across tests. A broader mechanism family can remain stable while local realization differs. The enabling conditions can remain stable while the transition sequence varies. The trajectory can remain within the same basin while the path differs. The qualitative transformation can persist while timing changes. A project should report the level at which robustness is observed instead of promoting stability of a broad mechanism class into certainty about a specific micro-process.

Mechanism substitution is especially important. Two mechanisms can compensate for one another across cases or periods. Removing one modeled pathway can activate another. An institutional rule can replace an informal norm. A network pathway can bypass a failed channel. Robustness of the outcome under such substitution indicates resilience of the broader generative system, while robustness of the focal mechanism can be weak. Integrated research design should preserve this distinction.

Enabling and constraining conditions also require separate assessment. A mechanism can be stable conditional on an institutional arrangement, resource threshold, relational configuration, or historical regime. Varying that condition can deactivate the mechanism. Such conditionality does not invalidate the generative claim; it defines its scope. Robustness analysis should record which conditions are constitutive, enabling, modulating, or merely correlated with the process.

Feedback and adaptation complicate robustness further. A mechanism can alter the conditions under which it later operates. Actors can learn, institutions can respond, networks can rewire, and categories can change. Robustness assessed only near the initial state can therefore miss transformations of the generative rule. Projects that investigate adaptive systems should examine whether the proposed account remains adequate after endogenous changes in relations, capacities, or rules.

Counterfactual variation provides another route. If a proposed mechanism predicts distinct traces or trajectories under plausible counterfactual conditions, the project can compare those implications with observed variation, historical negative cases, interventions, simulations, or process evidence. Generative robustness increases when the account continues to constrain plausible histories rather than being flexible enough to accommodate every outcome after the fact.

Proposition 9.176 (Mechanism-level robustness discipline). *Robustness of a generative conclusion should be reported at the deepest generative component that remains supported across the justified contrast class, with weaker or unresolved components retained as explicit qualifications.*

Proposition 9.176 guards against overstatement. Evidence can support a broad feedback structure while leaving the exact micro-mechanism open. It can support a threshold transition while leaving the threshold value uncertain. It can support path dependence while leaving the initial branching event contested. The robustness architecture should preserve the strongest supported component without silently filling unresolved levels.

Generative fragility can be substantive. A process near criticality can genuinely change trajectory under small perturbations. A path-dependent institution can be highly sensitive to early sequence. A generative system can contain multiple basins with narrow boundaries. In such settings, low trajectory robustness can coexist with robust knowledge of the generative structure that produces sensitivity. The project should therefore distinguish fragility of realized outcomes from fragility of the explanatory architecture.

9.13.5 Cross-Method Robustness

Cross-method robustness concerns the stability of a claim across methodologically differentiated routes of inquiry. Its role in Chapter 9 is project-level coordination. Earlier methodological chapters established the value of differentiated evidence pathways and the stability of generative claims across methods; Section 9.10 then developed adjudication when those methods converge, diverge, or conflict. The present subsection asks which parts of the integrated project retain warrant after that adjudicative process. Its objective is to turn methodological plurality into a documented robustness profile without reducing agreement to vote counting.

Methods can differ in their access to the object. Historical reconstruction can reveal sequence and institutional formation. Interviews can reveal interpretation and situated mechanism. Quantitative longitudinal analysis can characterize temporal association or heterogeneous response. Network analysis can reconstruct propagation or position. Formalization can expose logical implications and non-identifiability.

Simulation can test generative sufficiency within a model. Intervention can provide evidence under controlled change. Interpretive inquiry can identify category meaning and contested manifestation. Cross-method robustness is strongest when these different access routes constrain compatible components of the claim.

Definition 9.177 (Project cross-method robustness). *Project cross-method robustness* is the stability of specified claim components across methodologically differentiated forms of inquiry after their evidential provenance, assumptions, representations, failure modes, and adjudicative relations have been made explicit.

This definition makes adjudication prior to robustness interpretation. Apparent convergence can arise from shared data, shared classifications, common assumptions, or direct calibration. A qualitative coding scheme can be constructed from the same institutional categories later used in a quantitative model. A simulation can be calibrated to summary statistics that also define its validation target. Several estimators can share one identification assumption. The project should therefore trace methodological dependence before treating convergence as cross-method reinforcement.

Partial convergence can still be powerful. A historical reconstruction can support the timing of a transition while a network analysis supports the propagation structure and interviews support the interpretive mechanism. These methods do not produce the same output, yet they can jointly support a multi-component generative account. Cross-method robustness should therefore operate on decomposed claim components and their dependency structure.

Divergence can also yield robustness at a higher level. Two methods can disagree about magnitude while agreeing that an effect is directionally positive. They can disagree about actor-level motives while agreeing on a structural constraint. They can produce different local classifications while identifying the same boundary transition. The robustness architecture should record the level at which agreement survives instead of treating any disagreement as project failure.

Contradiction requires stronger revision. Section 9.10 specified that conflict should first be localized to evidence, representation, assumptions, scale, interpretation, or method. After localization, the project can reassess robustness. A claim that survives revision across methods can regain support. A claim that requires privileging one weakly justified method should be reported as method-dependent. A conflict that remains irreducible should remain part of the robustness record.

Proposition 9.178 (Differentiated methodological constraint). *Cross-method robustness increases when methodologically differentiated inquiries constrain compatible components of a claim through partially independent evidence, assumptions, representations, or failure modes, with remaining disagreements preserved at their actual locus.*

Methodological redundancy can be designed deliberately. A project can include two approaches whose failure modes differ even when one is not required for primary identification. Historical evidence can stress-test a statistical periodization. Qualitative process evidence can stress-test a mechanism assumed in a formal model. A formal model can expose hidden assumptions in narrative reasoning. Such redundancy is valuable when it creates genuine mutual constraint. Repeating essentially

the same analysis in several software environments provides a different function, closer to computational reproducibility.

The project should also preserve method-specific residues. Some interpretive content cannot be translated into a numerical variable without loss. Some formal implications have no direct observational analogue. Some historical evidence supports a singular event sequence that does not transfer naturally to a population estimate. Cross-method robustness is compatible with these irreducible components. Their preservation maintains methodological pluralism while clarifying which parts of the integrated conclusion receive cross-method support.

9.13.6 Cross-Case Robustness

Cross-case robustness concerns the stability or structured transfer of a claim across cases selected for explicit inferential roles. Its role is to connect the case-selection architecture of Section 9.4 with the evaluation of how far a finding can travel. Its objective is to distinguish case-specific insight, scope-bounded transfer, and more widely stable relational or generative structure. The method compares the target claim across typical, critical, deviant, historical, comparative, boundary, negative, or generative cases while preserving the conditions that make the cases comparable or intentionally different.

Case robustness does not require identical outcomes. A generative mechanism can produce different manifestations under different local conditions. A relational pattern can preserve its structure while changing actor identity. A policy process can exhibit the same bottleneck at different institutional locations. A value-conversion pathway can persist while the value forms being converted differ. Cross-case robustness can therefore concern invariant structure, conditional regularity, or coherent transformation.

Definition 9.179 (Cross-case robustness profile). A *cross-case robustness profile* records whether specified claim components remain supported, require condition-specific qualification, or transform according to a defensible comparative logic across cases selected for explicit inferential roles.

The inferential role of each case matters. A typical case can show operation under common conditions. A critical case can test a demanding implication. A deviant case can reveal omitted mechanisms or hidden heterogeneity. A boundary case can locate where a claim ceases to hold. A negative case can test enabling conditions. A historical comparison can reveal transformation of the generative rule. Treating all cases as exchangeable observations would erase these different contributions.

Case comparison should therefore begin from a transfer proposition. The project should identify which component is expected to persist and which conditions can legitimately vary. A claim about a mechanism can require similar enabling conditions but allow institutional form to differ. A claim about field structure can allow actor identities to vary while preserving positional relations. A claim about a historical transition can require sequence similarity while allowing timing to differ. The transfer proposition makes the robustness test explicit.

Deviant and negative cases are particularly informative. A claim that appears

stable across several confirming cases can remain weakly tested if all cases share the same favorable conditions. A deviant case can reveal that one omitted relation changes the mechanism. A negative case can show that an enabling condition is more specific than expected. Robustness can increase after such cases narrow the claim, because the revised scope becomes better supported.

Case dependence should also be distinguished from selection dependence. If the case portfolio was selected using the same outcome later used to claim robustness, the apparent stability can be partly induced by selection. Purposive selection remains valuable, but its logic should be documented. The project should state whether cases were chosen for variation in outcome, mechanism, boundary, institutional setting, scale, historical phase, or evidential access.

Proposition 9.180 (Case-relative transfer). *Cross-case robustness supports transfer only to the extent that the case portfolio varies conditions relevant to the target claim and that the conditions preserved across cases are sufficient to justify the proposed comparative relation.*

This proposition favors calibrated transfer over generic external validity language. A claim can be robust across a family of cases sharing one institutional structure and remain untested elsewhere. Another claim can survive sharply different contexts because it concerns a more abstract relational constraint. A third can exhibit a reproducible transformation rule across contexts. Each result has a different scope.

Cross-case robustness can also reveal typologies. If several cases organize into distinct robustness regimes, the project can replace a single general claim with a conditional typology. One mechanism can dominate in centralized systems, another in decentralized systems, while a shared relation constrains both. Such a typology can be more informative than forcing all cases into one averaged conclusion.

9.13.7 Cross-Scale Robustness

Cross-scale robustness concerns the stability or coherent transformation of a claim across spatial, temporal, organizational, relational, or analytical scales. Its role is to evaluate whether conclusions depend on one level of aggregation or remain meaningful when the research object is re-expressed at another scale. Its objective is to distinguish scale-invariant structure, scale-specific mechanisms, emergent properties, and supported bridge relations. The analysis compares claims across explicitly defined scales while documenting aggregation, disaggregation, and translation rules.

Scale changes can transform the object rather than merely resize it. Individual interactions can generate organizational routines. Organizational routines can contribute to field-level constraints. Short-term fluctuations can aggregate into long-term trends, while long-term institutional change can alter short-term behavior. Local network closure can coexist with system-level openness. A cross-scale robustness architecture therefore needs to preserve emergence and downward constraint as possibilities.

Definition 9.181 (Cross-scale robustness profile). *A cross-scale robustness profile records which components of a claim remain invariant, remain directionally or structurally stable, transform according to supported bridge relations, or become*

scale-specific when the relevant spatial, temporal, organizational, relational, or analytical scale changes.

Aggregation can create apparent robustness. A stable population average can conceal heterogeneous subgroup trajectories. A smooth macroeconomic trend can coexist with unstable organizational processes. A network-level density measure can remain stable while tie composition changes substantially. Robustness at a coarser scale therefore should not automatically be transferred to finer-scale mechanisms.

Disaggregation can create the opposite problem. A project can identify highly variable local behavior even when the higher-level structure remains stable. Such variation can be compatible with robust macro-organization if many micro-configurations generate the same higher-level pattern. The research question determines whether this multiplicity weakens or strengthens the claim. A claim about macro-structure can gain robustness from micro-level equifinality, while a claim about a specific micro-mechanism can lose robustness.

Temporal scale deserves similar care. A relation can be positive over short horizons and neutral or negative over longer horizons because feedback, adaptation, depletion, or institutional response changes the process. A robust short-term intervention effect can therefore coexist with weak long-term robustness. Cross-scale analysis should treat horizon as part of the claim.

Bridge rules are central. If a project asserts that a relation at one scale generates or constrains a pattern at another, it should specify the transformation connecting them. Aggregation functions, network coarse-graining, institutional nesting, temporal accumulation, causal pathways, or qualitative translation rules can provide such bridges. The bridge itself can be subjected to sensitivity and robustness analysis.

Proposition 9.182 (Scale coherence). *Cross-scale robustness is supported when a claim either remains stable across relevant scales or changes according to an explicitly specified and evidentially supported bridge relation, with scale-specific losses and emergent properties preserved in the interpretation.*

Proposition 9.182 makes cross-scale robustness compatible with emergence. A relation need not look identical at every level. The stronger requirement is coherence between the scale-specific claims and the transformation connecting them. A field-level constraint can emerge from many local interactions and then alter local possibilities. A cross-scale architecture can represent this recursive relation without reducing one scale to another.

Scale fragility can again be substantive. A mechanism that exists only within a narrow organizational scale can reveal where coordination changes form. A pattern that disappears under longer temporal aggregation can indicate episodic rather than structural behavior. A finding that reverses across scales can expose aggregation effects or genuinely opposing processes. Robustness analysis should identify which interpretation is supported by evidence.

9.13.8 Scope Conditions and Interpretive Boundaries of Robustness

The preceding dimensions make robustness a powerful project-level discipline, but its epistemic meaning remains bounded. The role of this final subsection is to specify

those boundaries before the chapter turns to uncertainty architecture. Its objective is to distinguish robustness from certainty, truth, causal identification, generality, predictive adequacy, practical importance, and normative acceptability. The discussion then consolidates the section into an integrated robustness record that can guide later revision and reporting.

Robustness does not eliminate uncertainty. A conclusion can remain stable across several defensible analyses while the evidence remains sparse. Another conclusion can be estimated precisely within one model while changing substantially across alternative models. A historical claim can be robust to periodization and still depend on incomplete archives. Robustness and uncertainty therefore describe different features of epistemic standing. Section 252 develops the uncertainty architecture explicitly.

Robustness also does not guarantee truth. Several methods can reproduce the same error when they inherit a shared classification, dataset, institutional perspective, or theoretical assumption. Multiple archives can reflect the same record-making asymmetry. Several models can share a common structural omission. Cross-case agreement can result from a narrow case-selection frame. The project should therefore preserve common dependencies and plausible omitted alternatives even when the observed robustness profile is strong.

Generality has a separate status. A claim can be robust within a narrow and well-specified domain. This can represent stronger knowledge than a weakly supported universal formulation. Cross-case and cross-scale analysis can broaden scope when warranted, yet robustness inside the tested contrast class provides little basis for transfer beyond it. The project should report the tested domain and the basis for any extension.

Causal identification also requires its own warrant. A correlation can be stable across datasets and models while the causal structure remains unresolved. A mechanism narrative can be stable across interviews while alternative causal pathways remain possible. A simulation can robustly generate an observed pattern while empirical evidence for its mechanism is weak. Robustness can strengthen a causal or generative claim when the contrasts are causally discriminating, but stability alone does not establish causality.

Predictive adequacy and explanatory adequacy can diverge. A robust predictive model can rely on features with limited explanatory interpretation. A generative model can explain a historical process while having limited forecasting range because future institutions or rules can change. A project should identify which function is being made robust: description, reconstruction, explanation, prediction, evaluation, or intervention guidance.

Practical and normative significance also remain distinct. A small effect can be statistically and methodologically robust while having limited practical importance. A large and robust effect can still be normatively ambiguous when benefits and burdens are distributed unevenly. An intervention can be robustly effective for one objective while constraining capabilities valued under another normative framework. Robustness architecture should therefore feed into normative and application-dominant praxis without substituting for them.

A further boundary concerns the contrast class. Researchers can always imagine additional perturbations. Robustness assessment becomes tractable by selecting alternatives justified by evidence, theory, historical dispute, methodological practice, model uncertainty, or practical relevance. This boundedness should be documented. A robustness result is always robustness relative to a specified family of alternatives.

Definition 9.183 (Integrated robustness record). *An integrated robustness record documents, for each consequential claim, the robustness dimensions examined, the justified contrast sets, the form of stability observed, the dependencies among tests, the components that remain sensitive or unresolved, the resulting scope qualification, and the evidence or design change that could materially revise the assessment.*

The record can be compact while remaining structured. For each claim, it can state that evidential support is stable across source families but dependent on one measurement definition; relational structure is stable within two plausible field boundaries; historical interpretation changes before a specified regime transition; the mechanism class is stable while the exact pathway remains open; cross-method support is differentiated but partly shares data; cross-case transfer holds within one institutional family; and cross-scale coherence is established only between organizational and field levels. This profile is far more informative than a single robustness label.

The integrated record also supports prioritization. A project with strong evidential and cross-method robustness but weak historical robustness should invest in periodization and archival reconstruction. A project with strong historical robustness but weak generative robustness should seek mechanism-discriminating evidence. A project with strong case-level robustness but weak cross-scale coherence should investigate bridge relations. Robustness analysis therefore functions as a map of where additional inquiry has the highest inferential value.

Proposition 9.184 (Robustness-scope discipline). *The warrant contributed by robustness analysis should be limited to the claim components, contrast classes, and forms of stability actually examined, with shared dependencies and unresolved sensitivity retained as part of the final epistemic statement.*

Proposition 9.184 completes the transition from sensitivity mapping to stability evaluation. Robustness architecture strengthens integrated research design when it identifies where a conclusion persists, how it transforms, what dependencies remain, and how far the resulting warrant can travel. Its contribution is therefore diagnostic and calibrating. It supports stronger claims where differentiated stability is demonstrated, narrower claims where dependence is localized, and targeted revision where fragility remains consequential.

The next task is to organize the uncertainty that remains even after sensitivity and robustness analysis. Uncertainty can enter through the status of the underlying object, the reconstruction of relations, the manifestations through which those relations are observed, measurement, historical evidence, model structure, generative attribution, and normative judgment. Section 252 develops this uncertainty architecture so that residual uncertainty remains part of the project design rather than appearing only as a qualification at the end of reporting.

9.14 Uncertainty Architecture

Sections 9.11–9.13 established three complementary disciplines for integrated research design. Model–evidence dialogue specifies how empirical confrontation can revise a research representation at different depths. Sensitivity analysis maps how specified conclusions depend on defensible perturbations in the research architecture. Robustness analysis evaluates which components remain stable, transform coherently, or require narrower scope across justified contrast classes. The present section organizes the residual openness that remains after these procedures. Its role is to make uncertainty an explicit component of project architecture rather than a generic qualification added at the end of reporting. Its objective is to distinguish ontological, relational, manifestational, measurement, historical, model, generative, and normative uncertainty, and then to specify how these forms should be communicated. The section proceeds from uncertainty concerning the status and characterization of the research object through the evidential and inferential layers of inquiry to uncertainty in evaluative judgment. The method is claim-relative and provenance-sensitive: each uncertainty statement identifies where uncertainty enters, what part of a claim it affects, how it has been investigated, what remains unresolved, and what future evidence or revision could change its status.

Uncertainty in a GR research project is therefore structured rather than homogeneous. A project can possess strong measurement precision while remaining uncertain about whether the measured variable adequately manifests the target relation. It can reconstruct a relation with substantial confidence while remaining uncertain about its generative contribution. It can produce a robust historical interpretation while leaving the ultimate ontological characterization of its objects under suspension. It can identify a stable empirical pattern while remaining uncertain about the normative significance of that pattern. Compressing these different states into one confidence label would obscure the location and meaning of the remaining openness.

The architecture also preserves a distinction developed earlier in the book between uncertainty and ontological suspension. Ontological suspension is a methodological discipline governing the strength of ontological commitment. Uncertainty concerns residual openness within a specified inquiry. A project can suspend a stronger metaphysical claim without being uncertain about a more limited relational claim that is sufficient for the analysis. Conversely, a project can make an operational ontological commitment and still face substantial uncertainty about whether that commitment is the best available characterization of the target. The two ideas interact, yet neither reduces to the other.

Definition 9.185 (Project uncertainty architecture). A *project uncertainty architecture* is the documented organization of materially relevant uncertainties across the ontological, relational, manifestational, measurement, historical, model, generative, and normative dimensions of a research project, together with their provenance, interactions, scope effects, expression formats, and revision conditions.

Definition 9.185 shifts attention from the quantity of uncertainty to its structure. Two projects can have similar aggregate levels of confidence while differing radically in what remains unresolved. One can face narrow parameter uncertainty around a well-established mechanism. Another can face a deeper ambiguity concerning the re-

lation being measured. A third can possess strong empirical findings and substantial normative uncertainty because several evaluative criteria remain defensible. These projects require different forms of additional inquiry and different modes of reporting.

The relation to sensitivity and robustness can now be stated precisely. Sensitivity asks how an inference changes when defensible elements of the research architecture are perturbed. Robustness asks what remains stable or transforms coherently across those perturbations. Uncertainty asks what remains open after the available evidence, comparisons, and revisions have been considered. A robust conclusion can remain uncertain in a dimension that the robustness analysis does not resolve. A sensitive conclusion can be well understood if the sensitivity itself is a stable property of the generative system. Uncertainty can also be robust: several methods, models, and evidence streams can converge on the conclusion that a particular distinction remains underdetermined.

Proposition 9.186 (Residual uncertainty after robustness). *Robustness reduces uncertainty only with respect to the claim components and contrast classes that the robustness analysis actually constrains; uncertainty located in other components of the project remains part of the warranted epistemic statement.*

Proposition 9.186 prevents stability from being interpreted as comprehensive closure. A relation can be robustly reconstructed across datasets while its historical origin remains uncertain. A mechanism class can remain robust across models while the exact pathway is unresolved. A normative judgment can remain stable across several empirical reconstructions while depending on a contested distributional principle. The project should preserve these distinctions instead of allowing strength in one dimension to compensate silently for openness in another.

Table 9.5 summarizes the principal dimensions developed below. The table distinguishes the analytical locus of each form, a characteristic question, useful expression formats, and a common form of false compression. The rows are analytically separable, yet they frequently interact. Measurement uncertainty can increase manifestational uncertainty; historical uncertainty can widen the admissible model set; ontological uncertainty can motivate several relational representations; normative uncertainty can depend on uncertainty about distributional effects. Integrated design should record these interactions explicitly.

A project can use these dimensions to build an uncertainty register alongside its data, model, decision, and revision records. The register does not require every uncertainty to be quantified. Quantification is appropriate when the relevant uncertainty has a defensible probabilistic, interval, or set-valued interpretation. Other uncertainties require alternative models, bounded qualitative categories, competing historical reconstructions, explicit assumptions, or narrative statements of unresolved interpretation. The expression format should follow the epistemic structure of the uncertainty rather than the availability of a numerical tool.

Definition 9.187 (Integrated uncertainty record). *An integrated uncertainty record documents, for each consequential claim, the uncertainty dimensions materially relevant to that claim, the evidence and assumptions that generate or constrain them, their interactions with sensitivity and robustness findings, the expression format*

Table 9.5: Dimensions of uncertainty in integrated GR research design

Uncertainty dimension	Characteristic question	Suitable expression	False compression to avoid
Ontological	Which characterization of the target is warranted or operationally necessary?	Competing ontological descriptions, suspended commitments, scope-indexed assumptions	Treating analytical usefulness as final ontology or treating suspension as ignorance
Relational	What relation exists, among which relata, with what properties and persistence?	Alternative relational reconstructions, bounded classifications, confidence profiles	Treating observed interaction or category membership as a fully identified relation
Manifestational	How do relational states generate or condition the traces available to inquiry?	Alternative manifestation mappings, source-production accounts, trace triangulation	Equating accurate observation of a trace with direct observation of the relation
Measurement	How accurately and reproducibly are specified manifestations recorded or quantified?	Error ranges, reliability estimates, calibration information, coding uncertainty	Allowing measurement precision to stand in for construct or relational validity
Historical	Which temporal reconstruction, sequence, context, and archive best support the claim?	Alternative chronologies, periodizations, source gaps, historically bounded scenarios	Treating surviving records or one periodization as a complete historical interior
Model	Which parameterization, structure, category system, or model family remains admissible?	Parameter regions, model sets, comparative diagnostics, structural alternatives	Reducing structural or categorical uncertainty to parameter error
Generative	Which mechanisms, conditions, feedbacks, and trajectories produced the observed difference?	Mechanism sets, pathway alternatives, counterfactual ranges, attribution profiles	Inferring a unique generative history from a stable outcome
Normative	Which evaluative criteria, standpoints, weights, and comparisons are warranted?	Criterion profiles, distributional decompositions, plural evaluations, threshold ranges	Presenting a normative conclusion as if it followed directly from empirical evidence

used, the present effect on claim scope, and the observations or revisions that could materially change the assessment.

The record in Definition 9.187 provides the project-level counterpart to the epistemic confidence profile developed earlier in the book. The earlier profile asks where warrant is strong or limited for a specified claim. The present record embeds that assessment in a complete research workflow. It connects uncertainty to design choices, model revision, methodological adjudication, documentation, future reanalysis, and communication. This makes uncertainty actionable without implying that every uncertainty can or should be eliminated.

9.14.1 Ontological Uncertainty

Ontological uncertainty concerns unresolved questions about how the target of inquiry should be characterized at the level required by the research problem. Its role in integrated design is to make ontological commitments visible and revisable rather than allowing them to remain hidden inside categories, models, or data structures. Its objective is to distinguish uncertainty about an analytical object's ontological characterization from both ontological suspension and uncertainty about empirical measurement. The inquiry asks which ontological distinctions are necessary for the claim being made, which alternatives remain compatible with the evidence, and what additional burden a stronger commitment would impose.

A research project inevitably operationalizes some ontology. It decides what counts as an actor, relation, event, institution, capacity, resource, field, process, or value form. A network model can treat organizations as nodes. A historical reconstruction can treat a legal change as an event. A survey can treat a reported category as an attribute. A simulation can treat an institutional rule as a transition condition. These decisions make inquiry possible, yet their usefulness does not establish that the chosen objects possess a final or unique ontological status.

Ontological uncertainty appears when more than one characterization remains analytically plausible and the distinction matters to the research claim. A digital platform can be represented as a firm, an infrastructure, a rule system, a relational field, or a hybrid configuration. A collective can be represented as an aggregate of individuals, an organized actor, or a relationally stabilized subject. An economic resource can be treated as a material object, a capability, an institutional entitlement, or a position within an access relation. Several descriptions can illuminate different generative properties without being mutually reducible.

Definition 9.188 (Inquiry-relative ontological uncertainty). *Inquiry-relative ontological uncertainty* is the residual plurality or incompleteness of warranted ontological characterization that remains relevant to a specified research claim after the project's operational commitments and available evidence have been made explicit.

The phrase *inquiry-relative* is essential. The definition does not claim that reality itself is indeterminate. It states that the project lacks sufficient warrant, need, or discriminating evidence to settle among ontological characterizations at the level relevant to the inquiry. This preserves the distinction between uncertainty concerning knowledge and stronger metaphysical claims about indeterminacy.

Ontological uncertainty can be managed through layered commitment. A project can commit strongly to the existence of a persistent relational configuration while suspending whether that configuration is ontologically fundamental. It can commit to the practical agency of an organization while leaving open whether organizational agency is reducible to individual agency. It can analyze an emergent field without deciding whether fields constitute a universal ontology. Layered commitment allows the research to proceed while preventing a local representation from becoming a concealed metaphysical conclusion.

Operational choices should therefore record their ontological burden. If a model requires stable actor identities, the project should state how identity persistence is established. If a historical analysis requires events to be individuated, it should state the event criteria. If a relational model requires distinct entity types, it should record how those types are produced and whether they can change. If a generative account treats a category as causally efficacious, it should distinguish the category's institutional efficacy from any claim that the category describes a natural kind.

Proposition 9.189 (Ontological-burden discipline). *An integrated research design should make only the ontological commitments required to support its target inferences, while recording materially relevant alternative characterizations whose adoption would alter representation, evidence, or generative interpretation.*

Proposition 9.189 turns ontological restraint into a design rule. It also provides a bridge to sensitivity analysis. When alternative ontological characterizations can

be operationalized, the project can test whether the substantive conclusion depends on them. When they cannot be translated without major conceptual loss, the alternatives should remain documented as distinct interpretive possibilities rather than being forced into a common metric.

Ontological uncertainty can diminish through evidence, conceptual clarification, or changing research purpose. It can also increase when a project encounters new entities, relations, or processes that earlier categories cannot adequately describe. A longitudinal project can therefore revise its ontological commitments during inquiry. Such revision is not automatically a defect. It can represent learning about the constitution of the research object.

9.14.2 Relational Uncertainty

Relational uncertainty concerns the reconstruction of relations among the objects provisionally admitted by the inquiry. Earlier epistemological analysis distinguished uncertainty about whether a relation exists from uncertainty about its type, direction, strength, meaning, persistence, and efficacy. The present subsection places those distinctions inside integrated project design. Its role is to specify how alternative relational reconstructions should be retained, compared, and propagated into later inference. Its objective is to prevent observed association, recorded interaction, or shared classification from being treated automatically as a fully identified substantive relation.

The uncertainty can enter through several components. Relata can be incompletely identified. A relation can be latent, intermittent, mediated, multiplex, strategically concealed, or differently interpreted by its participants. Direction can be uncertain. The same interaction can contain cooperation and dependence. Formal equality can coexist with practical asymmetry. Recorded membership can coexist with marginal participation. Repeated exchange can coexist with weak trust. A project should therefore decompose the relational claim before assigning confidence.

Boundary choice further shapes relational uncertainty. A relation can appear direct when intermediaries are excluded from the field. A local network can appear sparse because relevant cross-boundary ties are omitted. Organizational categories can aggregate actors whose internal relations are generatively important. Sensitivity analysis can reveal whether boundary alternatives materially change the reconstruction, but residual relational uncertainty remains when evidence does not discriminate adequately among plausible structures.

Definition 9.190 (Relational reconstruction set). A *relational reconstruction set* is the documented set of relational structures or classifications that remain materially compatible with the available evidence for a specified inquiry, together with the evidence that differentiates them and the claims that remain invariant or variable across the set.

The reconstruction set can be simple or formal. A qualitative study can preserve two competing interpretations of an authority relation. A network analysis can retain several plausible edge sets under different missing-data assumptions. A historical project can preserve alternative reconstructions of an informal coalition. A legal-economic inquiry can distinguish formal contractual relations from effective control

relations. The aim is not to multiply alternatives indefinitely. It is to retain those differences that alter a consequential inference.

Relational uncertainty can itself be structured by resolution. Evidence can strongly establish that a dependency relation exists while weakly determining its precise subtype. It can establish direction but not intensity. It can establish repeated interaction while leaving meaning contested. In such cases, the warranted response is often to lower classificatory resolution rather than to force a more precise category. Integrated design should record the deepest relational characterization that remains supported.

Relational uncertainty also propagates. If a generative claim depends on a hierarchy that is only weakly reconstructed, generative uncertainty should reflect that dependence. If a normative claim concerns unequal burden across a relation whose direction is uncertain, the normative assessment should not silently assume the disputed direction. Propagation prevents downstream claims from acquiring greater apparent certainty than their upstream relational premises support.

Proposition 9.191 (Propagation of relational uncertainty). *When a downstream inference depends materially on an unresolved relational property, the uncertainty attached to that property should remain visible in the downstream claim unless independent evidence constrains the inference through another route.*

This proposition does not require uncertainty to accumulate mechanically. Independent evidence can constrain a downstream conclusion even when one upstream relation remains open. The project should therefore track dependence rather than simply adding uncertainty labels. A relation can be uncertain in one dimension and irrelevant to another inference. The architecture gains value by showing which uncertainty matters where.

9.14.3 Manifestational Uncertainty

Manifestational uncertainty concerns the mapping from relational reality to the traces, symbols, records, observations, and representations through which that reality becomes accessible to inquiry. Its role is to preserve the non-invertibility of manifestation inside project design. Its objective is to distinguish uncertainty about what a trace means from uncertainty about whether the trace was measured accurately. The inquiry therefore examines the production of evidence before treating observed variables, documents, utterances, images, transactions, or logs as direct disclosures of the relation under study.

A trace can be measured with high technical precision while remaining manifestationally ambiguous. A platform log can record every click accurately while leaving the meaning of repeated interaction uncertain. An administrative database can faithfully reproduce official categories while those categories only partially manifest lived eligibility, practical access, or informal exclusion. A price series can be recorded precisely while the relation between price and value generation remains theoretically and historically mediated. An interview transcript can preserve words accurately while interpretation of the relation expressed through them remains open.

Manifestational uncertainty is reduced when the project studies the production

process of its evidence. Administrative procedures can reveal how categories enter records. Technical documentation can reveal what a logged event includes and excludes. Ethnographic inquiry can reveal how respondents interpret survey categories. Archival analysis can reveal which events institutions considered recordable. Legal analysis can distinguish formal recognition from implementation. These inquiries do not eliminate mediation; they make the manifestation relation itself an object of evidence.

Definition 9.192 (Manifestation mapping). *A manifestation mapping specifies the evidentially supported relation between a target relational state or process and the traces through which that state or process becomes available to inquiry, including known omissions, transformations, selection mechanisms, and alternative generative sources of the same trace.*

A project can maintain several manifestation mappings when the evidence permits more than one. Declining recorded use of a service can reflect declining demand, substitution into another channel, exclusion from access, changed logging rules, or strategic avoidance. A stable survey category can reflect stable experience or stable response conventions. A sudden documentary increase can reflect social change or a change in record-making practice. The research design should identify which alternatives can be discriminated and which remain open.

Triangulation can be especially valuable at this layer when manifestation processes differ. Administrative records, participant accounts, direct observation, and physical traces can share a target relation while possessing different production mechanisms. Convergence across such sources can constrain manifestational uncertainty more strongly than repetition within one record system. Cross-method agreement based on the same manifestation pipeline provides less independent constraint than it initially appears to provide.

Manifestational uncertainty also creates a reason for preserving source provenance. Later changes in knowledge about how records were produced can alter the interpretation of earlier evidence without changing the record itself. A future researcher can discover a classification rule, logging change, archival omission, or strategic reporting practice that changes the inferred manifestation mapping. This is one reason Section 253 places historical re-epistemization inside the research architecture.

Proposition 9.193 (Manifestation-source discipline). *The evidential force of an observed trace should be calibrated to the support for its manifestation mapping, with uncertainty about trace production distinguished from measurement error and retained when alternative relational sources remain plausible.*

9.14.4 Measurement Uncertainty

Measurement uncertainty concerns the accuracy, reliability, coding consistency, calibration, temporal resolution, spatial resolution, sampling, and processing through which specified manifestations are recorded or quantified. Its role is narrower than manifestational uncertainty but remains essential. Its objective is to identify how much uncertainty arises after a manifestation has been selected as evidentially relevant and before the resulting measurement enters inference or modelling.

The distinction between manifestation and measurement is analytically important. Suppose a survey item is accepted as one manifestation of perceived institutional trust. Measurement uncertainty can concern sampling error, response reliability, translation, scale coding, or instrument stability. Manifestational uncertainty concerns whether the response adequately manifests the relational phenomenon called trust. Improving sample size can reduce some measurement uncertainty without resolving the manifestation problem. Conversely, a carefully justified manifestation can still be measured imprecisely.

Measurement uncertainty can be expressed quantitatively when the measurement process supports such representation. Error bars, confidence intervals, posterior distributions, calibration curves, inter-coder agreement, missing-data ranges, and interval estimates can each be appropriate in different designs. The project should specify what the quantity represents. A narrow confidence interval around an estimated mean describes one form of sampling uncertainty; it does not summarize uncertainty about category construction, historical scope, causal mechanism, or normative meaning.

Qualitative and historical research also contain measurement-like operations. Dates can be uncertain within a range. Archival counts can be incomplete. Coding of documents can vary among researchers. Geographic boundaries can be recorded at different resolutions. Interview transcription can omit tone or gesture. Visual coding can depend on image quality. The absence of a conventional numerical instrument does not remove the need to document recording and coding uncertainty.

Definition 9.194 (Measurement uncertainty profile). *A measurement uncertainty profile records the principal sources of uncertainty introduced by the procedures used to observe, record, code, aggregate, transform, or quantify a specified manifestation, together with the scale and form in which each source can defensibly be expressed.*

Propagation into models should respect the measurement process. If a parameter is estimated from uncertain observations, the model can carry that uncertainty through simulation or inference where appropriate. If categories are coded with known disagreement, alternative codings can enter sensitivity analysis. If a time series contains a structural break caused by a measurement change, that break should be represented rather than treated as ordinary noise. The project gains little from precise downstream computation when uncertainty in the input process has been ignored.

Measurement uncertainty can also interact with scale. Aggregation can reduce some local noise while concealing heterogeneity. High-frequency measurement can reveal short-lived dynamics while increasing sensitivity to timing and missingness. Spatial aggregation can stabilize rates while erasing local relational structure. The measurement design should therefore be interpreted together with the scale architecture developed earlier in the chapter.

Proposition 9.195 (Measurement-meaning separation). *Improved precision in recording or estimation strengthens a research claim only to the extent that the measured manifestation and its relation to the target claim remain adequately justified.*

Proposition 9.195 guards against precision substitution. Technical accuracy is valu-

able, yet it cannot compensate by itself for ambiguity about what is being measured. Integrated uncertainty architecture therefore keeps measurement quality and manifestation validity in separate but connected records.

9.14.5 Historical Uncertainty

Historical uncertainty concerns uncertainty in the temporal reconstruction through which a project locates events, relations, categories, mechanisms, and transformations. Its role is to preserve the incompleteness and historically situated production of records while still permitting disciplined historical inference. Its objective is to identify uncertainty in chronology, periodization, sequence, source survival, context, category meaning, and retrospective interpretation. The project should distinguish a gap in surviving evidence from evidence of historical absence.

Historical records are generated selectively. Institutions record what their procedures make visible. Actors preserve some communications and destroy others. Archives inherit classification systems, access restrictions, preservation choices, and unequal record-making capacities. Informal relations can leave sparse traces. Marginalized actors can appear primarily through records produced by institutions acting upon them. Historical uncertainty therefore concerns both missing information and the structure through which information became preservable.

Chronology can remain open even when major events are known. Informal decisions can precede formal announcements. Institutional practices can change gradually before a legal reform. A technological transition can diffuse unevenly. Several candidate turning points can therefore remain plausible. Sensitivity to historical window and periodization can reveal whether a conclusion depends on one temporal division, while the uncertainty architecture records which temporal alternatives remain live after that comparison.

Sequence uncertainty matters especially for generative claims. If two events occur close together, the evidence can support several orderings. If the mechanism requires one event to activate another, sequence uncertainty directly limits generative attribution. A project can retain a partial order when the evidence supports precedence for some events while leaving others incomparable. This is often more faithful than forcing a complete chronology.

Definition 9.196 (Historical reconstruction envelope). A *historical reconstruction envelope* is the bounded set of chronologies, periodizations, source interpretations, and contextual reconstructions that remain materially compatible with the available historical evidence for a specified claim.

The envelope can be narrow around well-documented episodes and wider around poorly observed transitions. It can also vary across components of the same claim. A project can know the date of a formal decision precisely while remaining uncertain about the preceding negotiation, implementation sequence, or informal adaptation. Reporting should preserve this unevenness.

Historical categories require particular care. The meaning of terms such as worker, household, market, property, welfare, risk, or even firm can change across periods and institutions. A category stable in wording can shift in extension or practical mean-

ing. Historical uncertainty therefore includes uncertainty about translation between past and present categories. Versioned categories, developed further in Section 253, can preserve those changes instead of retrospectively imposing a single vocabulary.

Counter-histories can also remain epistemically useful. When two historical interpretations remain supported, the project can ask which later conclusions depend on choosing between them. Some relational or normative claims can remain stable across both. Other generative claims can diverge sharply. The uncertainty architecture should isolate the point of divergence so future evidence can target it.

Proposition 9.197 (Historical incompleteness discipline). *Absence, silence, or discontinuity in the surviving record should influence a historical claim according to the evidence concerning record production and preservation, rather than being interpreted automatically as absence of the underlying event, relation, or process.*

9.14.6 Model Uncertainty

Model uncertainty concerns the plurality and incompleteness of formal, statistical, computational, conceptual, or representational structures used to organize evidence and inference. Its role is to carry the model–evidence dialogue of Section 9.11 into the project’s residual uncertainty record. Its objective is to distinguish parameter uncertainty from uncertainty concerning structure, categories, mechanisms, model family, representation, and model purpose. The project should therefore identify the depth at which model plurality remains consequential.

Parameter uncertainty is the shallowest common form. The model structure is held fixed while parameter values remain uncertain within a defensible range or distribution. Structural uncertainty concerns the relations among model components: functional forms, network topology, transition rules, feedback structure, state variables, or causal ordering. Categorical uncertainty concerns whether the model’s distinctions adequately represent the target. Model-family uncertainty concerns whether a different formal or conceptual architecture could organize the evidence comparably well. These uncertainties have different implications and should not be collapsed into one numerical interval.

A project can obtain precise parameter estimates inside a poorly identified model family. It can also face wide parameter uncertainty while possessing strong evidence for the mechanism class. The epistemic interpretation therefore depends on the level at which the uncertainty sits. A narrow posterior distribution does not resolve structural alternatives excluded from the model. A successful simulation does not establish that its encoded categories are ontologically privileged. A high predictive score does not settle whether the model captures the generative relations of interest.

Definition 9.198 (Model uncertainty stack). *A model uncertainty stack records residual uncertainty across parameter, structural, categorical, mechanism, representation, and model-family levels, together with the empirical or theoretical comparisons that constrain each level.*

The stack complements the revision-depth architecture of Section 9.11. Revision identifies how deeply a mismatch requires the model to change. Uncertainty architecture records which depths remain open after the current round of confrontation

and revision. A project can therefore state that parameter uncertainty is narrow, structural uncertainty moderate, and categorical uncertainty substantial, rather than reporting a single model confidence judgment.

Multiple-model reasoning provides one response. Models can be compared for descriptive adequacy, explanatory adequacy, predictive performance, historical plausibility, generative interpretation, or intervention relevance. Different models can remain useful for different purposes. Preserving a model ensemble can be more informative than selecting one winner when the evidence does not warrant unique selection. The ensemble should record shared assumptions so apparent plurality does not exaggerate independence.

Model uncertainty can also be asymmetric in consequence. Two models can fit past observations similarly while generating different intervention implications. Another pair can differ in mechanism while agreeing on the narrow descriptive claim relevant to the project. The uncertainty record should therefore ask which downstream decision, interpretation, or theory revision depends on resolving the model difference.

Proposition 9.199 (Depth-indexed model uncertainty). *Model uncertainty should be reported at the deepest unresolved level that materially affects the target inference, with shallower precision prevented from concealing structural, categorical, or model-family alternatives.*

9.14.7 Generative Uncertainty

Generative uncertainty concerns residual openness about how a difference, capacity, relation, institution, trajectory, or transformation was produced, stabilized, inhibited, or altered. Its role is to preserve uncertainty in causal and generative reconstruction even when outcomes and relational patterns are well established. Its objective is to distinguish uncertainty about mechanism, enabling conditions, pathway, timing, feedback, threshold, counterfactual dependence, and cross-scale propagation. This dimension is central to GRE because the same manifest outcome can often be generated through several relational histories.

Generative uncertainty can begin with mechanism plurality. Several mechanisms can produce observationally similar traces. Institutional compliance can emerge through enforcement, legitimacy, habit, coordination, reputational effects, material incentives, or combinations of these processes. Market concentration can arise through scale economies, network effects, regulation, acquisition, financing constraints, or unequal access to infrastructure. Similar outcomes therefore provide incomplete discrimination among generative accounts.

Enabling conditions can be uncertain even when a mechanism is plausible. A feedback process can require a threshold resource level, an institutional rule, a network configuration, or a historical expectation whose presence is only partly observed. The project should distinguish evidence for the mechanism from evidence for the conditions that activate it. A mechanism that works in simulation under an assumed condition does not establish that the condition obtained historically.

Pathway uncertainty concerns the sequence and branching structure through

which a process unfolded. Several histories can connect similar boundary observations. A spin-foam-inspired or partially ordered representation can preserve alternative interiors without pretending that one unobserved history has been recovered directly. Historical simulation can likewise explore families of plausible trajectories rather than selecting one simulated path as the actual past.

Feedback introduces another layer. A mechanism can alter the relations and capacities that later modify the mechanism itself. Actors can learn; institutions can adapt; constraints can shift; categories can be redefined. Generative uncertainty can therefore concern changes in the rule of generation rather than merely uncertainty about a fixed process. Static causal language can become inadequate when the transformation changes the architecture through which later changes are produced.

Definition 9.200 (Generative uncertainty profile). *A generative uncertainty profile records the residual alternatives and confidence structure concerning mechanism, enabling and constraining conditions, sequence, pathway, feedback, thresholds, counterfactual dependence, scale propagation, and transformation of generative rules for a specified target difference.*

The profile can show that the mechanism class is well supported while the sequence remains uncertain; that the sequence is well documented while the counterfactual contribution is weakly identified; or that a threshold transition is evident while the threshold value and cross-scale propagation remain open. This component-wise structure prevents a broad claim such as “the mechanism is uncertain” from concealing what is actually known.

Equifinality and multifinality deserve separate attention. Equifinality permits several pathways to produce a similar outcome. Multifinality permits similar initial conditions or mechanisms to produce different outcomes under modest contextual differences. Both structures weaken deterministic reconstruction while strengthening the case for conditional generative claims. A research project can possess robust knowledge of an equifinal or multifinal architecture even when the realized path remains uncertain.

Substantive sensitivity near criticality can also generate legitimate generative uncertainty. Small differences in initial conditions, timing, or perturbation can change the realized trajectory. In such cases, uncertainty is not necessarily evidence of poor research design. The research can instead identify the generative conditions under which precise trajectory prediction becomes limited. This distinction is especially important when integrated research informs application-dominant praxis, where decision design may need to respond to structural unpredictability rather than waiting for impossible certainty.

Proposition 9.201 (Generative uncertainty and explanatory resolution). *A generative claim should be stated at the deepest level of mechanism, condition, pathway, or rule transformation that the available evidence discriminates, while unresolved finer-grained generative alternatives remain explicit in the uncertainty profile.*

9.14.8 Normative Uncertainty

Normative uncertainty concerns residual openness in the evaluative criteria, standpoints, thresholds, comparisons, weights, and principles through which empirical and generative findings acquire practical or ethical significance. Its role is to prevent normative judgment from being hidden inside technical choices while also preventing empirical uncertainty from being confused with normative disagreement. Its objective is to distinguish uncertainty about facts from uncertainty about how facts should be evaluated, particularly when several values remain legitimate and partially incommensurable.

Normative uncertainty can arise even when empirical knowledge is strong. A project can know with substantial confidence that a policy increases aggregate output while remaining uncertain about the acceptable distribution of gains and burdens. It can establish that an intervention expands one capability while constraining another. It can identify unequal exposure to risk while facing disagreement about compensation, priority, responsibility, or permissible trade-offs. The normative openness belongs to the evaluative architecture rather than to the empirical measurement alone.

The reverse also occurs. Normative principles can be relatively clear while empirical uncertainty limits their application. A commitment to avoiding severe irreversible harm can be stable, yet the probability and distribution of harm can remain uncertain. A commitment to equal standing can be clear while the relevant relational asymmetry is incompletely reconstructed. Integrated design should therefore preserve both dimensions and the dependence between them.

Definition 9.202 (Normative uncertainty profile). A *normative uncertainty profile* records the materially relevant plurality or incompleteness of evaluative criteria, affected standpoints, thresholds, weighting rules, comparability assumptions, distributional judgments, and principles of responsibility that bear on a specified research conclusion or practical recommendation.

The profile should preserve plural value forms when commensurability is not established. Economic value, capability, recognition, ecological integrity, institutional legitimacy, temporal burden, and relational autonomy need not be reducible to a single metric. A multi-criteria analysis can make trade-offs explicit, but the use of a common decision framework does not prove that the underlying values are intrinsically commensurable. Weighting choices should therefore be reported as normative inputs rather than discovered empirical facts.

Standpoint matters as well. Different groups can experience the same relation differently because positions, capabilities, risks, and historical burdens differ. Normative uncertainty can arise from incomplete representation of affected standpoints, disagreement within groups, or uncertainty about future stakeholders. Participatory inquiry can improve access to these perspectives without turning participation into automatic normative closure. The research design should record whose judgments entered the evaluation and which affected positions remain weakly represented.

Thresholds provide another source. A policy can be acceptable under one risk threshold and unacceptable under another. A distribution can be considered tolerable under one sufficiency criterion and unjust under another. Sensitivity analysis can show how conclusions vary across defensible thresholds; the uncertainty archi-

itecture records why more than one threshold remains normatively live and what additional argument or deliberation could narrow the range.

Normative uncertainty can itself be persistent and legitimate. Some conflicts reflect plural values whose complete ranking is neither available nor necessary for every decision. In such cases, the project can identify dominated options, robust prohibitions, shared minimum conditions, or decisions acceptable across several normative views without pretending to resolve the entire normative theory. This prepares the transition from research-dominant praxis to the application-dominant block developed later in the book.

Proposition 9.203 (Normative-empirical separation with interaction). *Normative uncertainty and empirical uncertainty should be documented separately while their dependencies are traced explicitly, so that empirical findings neither conceal evaluative premises nor become weakened merely because legitimate normative plurality remains.*

9.14.9 Communication of Uncertainty

Communication of uncertainty is the final component of the architecture because uncertainty that is carefully analyzed but poorly communicated can still produce overconfident interpretation. Its role is to translate the differentiated uncertainty record into forms appropriate to readers, collaborators, decision-makers, participants, and future researchers. Its objective is to preserve the location, magnitude where meaningful, provenance, scope, and practical implications of uncertainty without converting every form into a common numerical language. The communication strategy should match the epistemic structure of the uncertainty and the decision context in which the finding will be used.

The first requirement is localization. Statements such as “the result is uncertain” provide little guidance. The project should identify whether uncertainty concerns the relation, manifestation mapping, measurement, historical reconstruction, model structure, generative pathway, or normative criterion. It should also state which components remain comparatively well established. Localized communication prevents one unresolved element from casting vague doubt over the entire project and prevents one strong element from obscuring uncertainty elsewhere.

The second requirement is calibration. Terms such as possible, plausible, supported, strongly supported, robust, sensitive, unresolved, and speculative should be used consistently with the evidence and design. Numerical probabilities should be reserved for uncertainties that can defensibly bear probabilistic interpretation. Interval estimates should state what varies inside the interval and under which assumptions. Scenario ranges should not be presented as probability distributions unless probabilities have actually been justified. Qualitative uncertainty should be communicated through explicit alternatives, scope conditions, and revision triggers rather than through invented precision.

The third requirement is provenance. Readers should be able to identify why the uncertainty exists. An unknown can arise from sparse data, inaccessible evidence, non-invertible manifestation, model plurality, historical destruction, category instability, genuine system sensitivity, or unresolved normative disagreement. These sources imply different responses. More measurement can address some forms;

broader fieldwork can address others; conceptual revision, historical research, model comparison, deliberation, or cautious decision design can address still others.

Definition 9.204 (Uncertainty communication statement). An *uncertainty communication statement* is a claim-linked account of what remains uncertain, the dimension and source of that uncertainty, the evidence or comparison that constrains it, the effect on the claim's scope or use, and the conditions under which the assessment should be reconsidered.

The statement can accompany major results, figures, tables, models, and recommendations. For a quantitative estimate it can identify measurement and model uncertainty separately. For a historical claim it can identify missing archives and competing periodizations. For a generative account it can identify the supported mechanism family and unresolved pathway. For a normative conclusion it can identify the evaluative criteria and the range of defensible thresholds. The format can remain compact if the full uncertainty record is available elsewhere in the project documentation.

Communication should also preserve robust uncertainty. Sometimes the strongest conclusion produced by a project is that the evidence does not discriminate among several alternatives. If that result persists across methods, models, and source sets, the uncertainty itself is an important finding. Reporting it clearly can prevent false closure and identify high-value directions for future research.

Uncertainty communication has temporal consequences as well. A statement should indicate which new evidence, model revision, category change, or historical discovery could alter the assessment. This makes the result revisable in a structured way. Future researchers can then distinguish uncertainty that arose from the state of available knowledge from uncertainty that reflected an enduring feature of the target process.

Proposition 9.205 (Uncertainty-preserving communication). A *research communication preserves epistemic integrity when it expresses uncertainty at the level where that uncertainty arises, distinguishes quantified from non-quantified forms, identifies material dependencies, and calibrates the scope and use of the claim accordingly.*

The integrated uncertainty record completes the sequence begun with model-evidence dialogue, sensitivity analysis, and robustness architecture. Model-evidence dialogue reveals where representations require revision. Sensitivity analysis maps dependence on defensible alternatives. Robustness architecture identifies differentiated forms of stability. Uncertainty architecture records the residual openness that remains and communicates its location and consequence. Together these components allow integrated research design to support strong claims where warrant is differentiated and substantial, narrow claims where dependence remains consequential, and explicit openness where the evidence does not justify closure.

The next section extends this architecture across time. Uncertainty, categories, models, and interpretations can change when new records appear or later conceptual resources reveal features that earlier inquiry could not recognize. Section 253 develops a historical re-epistemization plan that preserves records, alternative models, superseded interpretations, context, and versioned analytical objects, enabling future inquiry to revisit the project's epistemic architecture.

9.15 Historical Re-Epistemization Plan

Section 9.14 completed the immediate epistemic architecture of an integrated research project by locating residual uncertainty after model–evidence dialogue, sensitivity analysis, and robustness assessment. The present section extends that architecture across historical time. Its role is to design the project so that later inquiry can reconstruct how its claims were generated and can reopen those claims when evidence, categories, methods, downstream consequences, or interpretive conditions change. Its objective is therefore broader than archival retention. A historical re-epistemization plan preserves the evidential and conceptual lineage required for future investigators to distinguish what the project knew, what it assumed, what it could not access, which alternatives it considered, why particular conclusions were adopted, and which later changes justify renewed analysis. The section proceeds through preservation of records, alternative models, superseded interpretations, context, versioned categories, versioned models, future reanalysis, and future reinterpretation. The method is temporal and provenance-centered: each component is evaluated by the future epistemic operations it enables rather than by the quantity of material retained.

Historical re-epistemization was introduced earlier in the book as disciplined reconstruction of an earlier relational or generative claim when later evidential or conceptual conditions materially alter what can be warranted. Chapter 9 translates that epistemic principle into research design. The translation matters because future revision is partly conditioned by choices made during the original inquiry. A project that preserves only its final paper can leave later researchers unable to identify how categories were operationalized, which records were excluded, how a model changed, why an interpretation was rejected, or which uncertainties were unresolved at closure. The nominal result survives while the epistemic pathway that produced it disappears.

The opposite extreme is equally unhelpful. Preservation cannot mean indiscriminate accumulation. Research materials can contain private information, legally restricted records, culturally sensitive materials, proprietary data, unstable software dependencies, redundant computational artifacts, or intermediate objects whose retention carries costs without meaningful future value. A re-epistemization plan therefore requires selection, documentation, access control, and explicit retention logic. The relevant criterion is reconstructive adequacy: whether a future inquiry can recover the relations among evidence, categories, representations, models, interpretations, decisions, and uncertainties that materially shaped the earlier claim.

A second distinction concerns historical openness. Re-epistemization does not imply that every concluded inquiry remains equally unsettled. Strong evidence can reject alternatives; careful adjudication can narrow interpretation; robustness analysis can support stable conclusions. The historical point is more specific. Even a well-supported conclusion is warranted under an identifiable epistemic state. Later records may appear, categories may change, computational techniques may improve, social practices may render previously weakly manifested relations visible, and downstream developments may reveal significance that was unavailable at the time. Preserving the earlier epistemic state makes it possible to determine

whether a later revision reflects new evidence, a new interpretation of old evidence, a transformed category system, a changed target relation, or some combination of these.

Definition 9.206 (Historical re-epistemization plan). A *historical re-epistemization plan* is the project-level architecture through which evidential records, provenance, contextual conditions, analytical categories, model states, serious alternative interpretations, uncertainty, and revision histories are preserved and versioned so that later inquiry can reconstruct an earlier epistemic state and reassess its relational or generative claims under materially changed conditions.

Definition 9.206 treats future revisability as part of present design. The plan need not predict the exact questions that later researchers will ask. Its task is to preserve enough structured optionality that later questions can be asked without forcing the earlier project to be reconstructed from final outputs alone. This includes the preservation of relations among materials. A file without provenance, a category without a definition history, a model without its data state, and a rejected interpretation without its adjudication record can each survive physically while becoming epistemically difficult to reuse.

The architecture also benefits from distinguishing an *as-of epistemic state* from the target process itself. The target can continue to evolve after the research period. The project's knowledge of that target can also evolve. The two histories should not be collapsed.

Definition 9.207 (As-of epistemic state). An *as-of epistemic state* is a time-indexed reconstruction of the evidence, category definitions, model versions, representations, interpretations, uncertainty assessments, and research decisions available to a project at a specified stage of inquiry.

An as-of state enables later investigators to ask a disciplined question: given what was available and how it was represented at that time, what conclusion was warranted? A later inquiry can then add new evidence or conceptual resources without silently importing them into the earlier state. This helps distinguish historical revision from retrospective judgment by later standards alone.

Table 9.6 summarizes the eight components developed below. The table connects each preserved object with the future epistemic operation it enables and the characteristic loss that occurs when the object is retained without sufficient lineage.

The table makes clear why historical re-epistemization is not reducible to data storage. It requires a linked architecture spanning empirical materials, conceptual objects, computational objects, judgments, and context. The following subsections develop those components in the order needed to preserve this lineage.

9.15.1 Preservation of Records

Preservation of records provides the evidential base of historical re-epistemization. Its role is to retain the materials through which later researchers can reconstruct what the project encountered and how those encounters became evidence. Its objective is to preserve source states, transformations, access conditions, exclusions, and inferential links at a level proportionate to the claims that depend on them. The rel-

Table 9.6: Components of a historical re-epistemization plan

Component	Material to preserve	Future epistemic function	Characteristic loss without lineage
Records	Source states, transformations, exclusions, access conditions, decision records, and evidential links	Reconstruction of how evidence entered and constrained the claim	Surviving data become detached from production and transformation conditions
Alternative models	Serious model families, assumptions, parameterizations, fit or confrontation results, and selection reasons	Reassessment when criteria, evidence, or modeling capabilities change	The selected model appears inevitable and model-selection uncertainty disappears
Superseded interpretations	Serious earlier interpretations, their support, conflicts, adjudication, and revision reasons	Recovery of interpretive pathways and unresolved alternatives	Hindsight converts contingent adjudication into apparent consensus
Context	Institutional, semantic, technological, field, evidential, and research conditions	Historically situated reconstruction of meaning and observability	Present categories or practices are projected backward without mediation
Versioned categories	Definitions, inclusion rules, operationalizations, mappings, and revision rationales	Comparison across changing classification regimes	Stable labels conceal semantic or relational transformation
Versioned models	Specifications, code or formal state, category and data dependencies, assumptions, environments, and outputs	Reconstruction of model evolution and earlier analytical states	Later model versions overwrite the inferential conditions of earlier results
Future reanalysis	Reconstructible inputs, processing lineage, comparison targets, and revision triggers	Re-examination with new evidence or methods while preserving the earlier analytical target	New results cannot be attributed to a specific evidential or methodological change
Future reinterpretation	Earlier epistemic state, historical semantics, alternative readings, and explicit new interpretive premises	Conceptual reconstruction when meaning, questions, or categories change	Later meaning is mistaken for earlier meaning or earlier categories become frozen

evant object is therefore a record lineage rather than a collection of files.

A project can produce several layers of records. Source records include interviews, field notes, archival images, administrative extracts, documents, sensor outputs, survey responses, digital traces, and other materials obtained from the field. Derived records include cleaned datasets, coded text, relational matrices, annotated corpora, extracted variables, embeddings, reconstructed timelines, and transformed archival materials. Analytical records include model inputs, diagnostic outputs, comparison tables, interpretive memos, adjudication notes, and sensitivity results. Decision records document why exclusions, recodings, category changes, boundary revisions, or model changes occurred. Historical re-epistemization can require access to several of these layers because later inquiry may challenge a transformation that the original project treated as routine.

Physical survival is therefore only the first condition. The future investigator also needs to know which source state generated which derived object, which operations intervened, and which analytical claims depended on the result. A cleaned table without its transformation history cannot reveal whether a later discrepancy originates in the source, the cleaning rule, the coding scheme, or the analysis. A quotation without document location and selection context can be difficult to reassess. A network edge without the extraction rule that generated it can survive as data while losing its relational meaning.

Definition 9.208 (Reconstructible project record). *A reconstructible project record is a preserved research object whose source, production or acquisition conditions, material transformations, access restrictions, relevant exclusions, and claim-linked analytical role are documented sufficiently for a later inquiry to determine how the object contributed to an earlier epistemic state.*

The definition permits proportionality. A small archival project does not require the infrastructure of a large computational collaboration. The requirement is that the lineage material to the claim remain recoverable. If a conclusion depends on manual coding, the codebook, coding decisions, category version, and important disagreements can be material. If a conclusion depends on an administrative extract, the query or selection conditions and the data dictionary can be material. If a historical argument depends on inaccessible or destroyed records, the absence itself and the basis for inferring it can be material.

Preservation should include negative and inaccessible states where they affect interpretation. A source that could not be obtained because an archive remained closed differs epistemically from a source that was inspected and found irrelevant. Missing years created by record destruction differ from years with documented absence of the target event. Participants who declined interview differ from actor positions that were never identified. Recording such distinctions enables future investigators to determine whether new access changes the evidential architecture or merely adds more material of the same kind.

Retention decisions also belong to the record. Privacy, consent, legal restrictions, community agreements, security concerns, or ethical obligations can justify deletion, aggregation, controlled access, or time-limited retention. Historical re-epistemization does not override those obligations. Where materials cannot be retained, the project can preserve metadata about their existence, role, restriction, transformation, or authorized destruction to the extent ethically and legally permitted. This creates a documented boundary around the future evidence base rather than a silent gap.

The project can consequently use differentiated preservation tiers. Some materials can be preserved in full; some can be retained in de-identified or transformed form; some can be described through metadata only; some can remain under controlled access; and some can require documented deletion. The tier itself should be linked to the reason for retention or restriction. Such differentiation improves future interpretation because the absence of a record then carries an intelligible status.

Proposition 9.209 (Lineage-preserving record retention). *The future re-epistemic value of a preserved record increases when its evidential lineage, transformation history, access status, and claim-linked function remain reconstructible, subject to the ethical and legal conditions governing retention.*

Proposition 9.209 shifts preservation from volume toward relational organization. A smaller archive with clear provenance can support stronger future reconstruction than a larger archive of disconnected artifacts. The proposition also prepares the later sections on documentation, reproducibility, and reusability, while the present focus remains narrower: maintaining the historical intelligibility of the evidential state from which the current project reasoned.

9.15.2 Preservation of Alternative Models

Preservation of alternative models extends the record from evidence to formal and computational representation. Its role is to prevent the project's final selected model from erasing the serious alternatives through which model uncertainty, structural assumptions, and selection criteria were assessed. Its objective is to preserve enough of the model set that future inquiry can determine which alternatives were genuinely considered, why particular models were preferred, and whether later evidence or analytical capabilities change that adjudication.

Section 9.11 treated model–evidence dialogue as recursive rather than as one-time model selection. Parameter revision, structural revision, category revision, method revision, theory revision, model replacement, and multiple-model reasoning can each produce a lineage of model states. At closure, one model may be used for the principal analysis while several others remain informative. Some alternatives may perform less well on the original criterion yet encode different mechanisms, category structures, or scale assumptions. Later evidence can alter their relative plausibility.

A useful archive therefore distinguishes serious alternatives from arbitrary model proliferation. Preservation should focus on model families or versions that performed a material epistemic role: models used to test a mechanism, challenge an assumption, represent a rival structure, explore uncertainty, reveal a category problem, or support a consequential robustness comparison. The archive can also preserve models rejected for identifiable reasons when those reasons could themselves become historically revisable.

Definition 9.210 (Alternative-model archive). An *alternative-model archive* is a versioned collection of materially relevant model families or states together with their assumptions, category and data dependencies, analytical roles, confrontation results, selection or rejection criteria, and relation to the claims for which they were considered.

The archive should distinguish several statuses. An alternative can be empirically disfavored under the available evidence, structurally incompatible with a well-supported relation, insufficiently identified, computationally intractable at the time, redundant for the focal claim, useful only under a narrower scope, or retained because several models remain observationally compatible. These statuses should not be compressed into the generic label “failed model.” The reason for non-selection determines whether later developments can reopen the model's role.

Consider a model that was rejected because required relational data were unavailable. Later digitization of archives can change that condition. A model rejected because its mechanism contradicts well-established evidence occupies a different status. A highly parameterized model set aside because the original sample could not identify its parameters may become usable after new data arrive. A model that fit well but depended on a category distinction later judged conceptually inadequate may require deeper revision rather than renewed estimation. Historical preservation makes these paths distinguishable.

Model selection criteria themselves can also change. A project may initially prioritize explanatory reconstruction, while later work prioritizes prediction, intervention, transfer, or interpretability. The same model set can then be evaluated differently

without implying that the earlier selection was irrational. Preserving the original purpose and criterion allows later investigators to interpret the change as a shift in epistemic task rather than a retrospective discovery that the project simply chose the wrong model.

Multiple-model reasoning is especially important where the evidence underdetermines structure. In such cases the archive should preserve the plurality rather than silently convert a working model into a uniquely established representation. This aligns with the uncertainty architecture of Section 9.14. Robust uncertainty can include robust model plurality: several differentiated analyses may agree that the available evidence does not discriminate among materially distinct formalizations.

Proposition 9.211 (Revisable model adjudication). *Model adjudication remains historically reconstructible when materially relevant alternative models are preserved with their epistemic roles, evidential confrontations, dependencies, and selection rationales, allowing later inquiry to distinguish a change in evidence or purpose from an undocumented change in model preference.*

Proposition 9.211 does not require preservation of every computational trial. The design criterion is epistemic materiality. Hyperparameter searches, temporary debugging states, and redundant intermediate runs can be summarized or discarded when they do not affect interpretation. Models that define a serious alternative inferential path warrant stronger preservation because their disappearance would narrow the future possibility of reconstructing the original model space.

9.15.3 Preservation of Superseded Interpretations

Interpretive lineage is the third component of the plan. Its role is to preserve serious readings that were revised, narrowed, subordinated, or rejected during inquiry so that the history of interpretation does not collapse into the final narrative. Its objective is to record the evidential basis, conceptual premises, conflicts, and adjudication through which interpretations changed. The relevant materials can include interpretive memos, coding rationales, alternative historical narratives, rival mechanism readings, field-based disagreements, participant interpretations, and cross-method conflicts.

A superseded interpretation can occupy several epistemic statuses. It can be contradicted by later evidence. It can lose support because a key source proves unreliable. It can remain plausible but weaker than a competing account. It can become restricted to a narrower scale or historical period. It can be displaced because a category changes. It can remain unresolved while the project adopts another interpretation for a particular analytical purpose. These paths have different implications for future re-epistemization.

The distinction matters because later research often encounters the final conclusion without the disagreement that made its scope visible. Hindsight can then make one interpretation appear self-evident. Preserving the interpretive lineage reveals which distinctions required judgment, which uncertainties remained live, and which evidence actually changed the balance among accounts. It also helps future researchers identify whether a later revival of an earlier interpretation reflects new evidence or merely forgetfulness about why it had previously been set aside.

Definition 9.212 (Interpretive lineage record). An *interpretive lineage record* documents materially relevant interpretations considered during inquiry, the evidence and conceptual premises supporting them, their relations of compatibility or conflict, the reasons for revision or non-selection, and any residual scope within which a superseded interpretation remains viable.

This record can be selective. Early speculative ideas that never shaped the inquiry need not all be archived as equivalent alternatives. The stronger case concerns interpretations that affected data collection, category formation, model design, case selection, field engagement, or consequential claims. Their preservation can explain why the project took the path it did.

Cross-method disagreement provides one important source of such lineage. Section 9.10 distinguished convergence, divergence, contradiction, unequal evidential strength, method-specific blind spots, and irreducible disagreement. Historical re-epistemization should preserve the adjudication state produced there. If one interpretation was favored because it explained archival evidence while another remained better aligned with field testimony, the later record should preserve that asymmetry. A future source can then alter the adjudication without requiring the disagreement to be rediscovered from the beginning.

Participant and positional interpretations can also require careful retention. Researchers may encounter accounts that were weakly represented in dominant records, institutionally marginalized, or difficult to translate into the project's initial categories. Preservation does not grant such accounts automatic evidential priority, yet their disappearance can make later reconstruction artificially homogeneous. Where ethically appropriate, the project can retain the existence, standpoint, evidential basis, and adjudicative status of these interpretations even when they are not adopted as the principal account.

Supersession should therefore be described by reason rather than by status alone. "Rejected" can hide whether the interpretation was empirically contradicted, conceptually incoherent, insufficiently evidenced, outside scope, normatively contested, or merely unnecessary for the focal conclusion. A later inquiry needs the reason because different historical changes can reopen different kinds of closure.

Proposition 9.213 (Hindsight-resistant interpretive preservation). *A project strengthens future reinterpretation when serious superseded or non-selected interpretations remain linked to their earlier evidence, conceptual premises, adjudication reasons, and residual scope, preventing later consensus from being inferred solely from the survival of the final narrative.*

Proposition 9.213 also protects the project from self-erasure. Research often advances through interpretations that were productive even when they were later revised. Preserving that history can reveal which questions, categories, or evidence streams made later insight possible. Historical re-epistemization therefore treats interpretive revision as part of the knowledge process rather than as noise to be removed from its public trace.

9.15.4 Context Preservation and Reconstruction

Records, models, and interpretations become historically intelligible only within context. The role of context preservation is to retain the conditions that shaped what could be observed, how categories were used, which actions were feasible, what evidence infrastructures existed, and how the research process itself interacted with the field. Its objective is to prevent later inquiry from treating earlier materials as semantically or institutionally self-sufficient. The relevant context includes the target process, the production of evidence, the conduct of research, and the later uses of research outputs.

Context is not an unlimited background. A re-epistemization plan should identify conditions that materially affect interpretation. Institutional rules can determine who appears in administrative data. Recording technologies can determine which interactions leave durable traces. Legal classifications can shape actor identities. Organizational incentives can influence reporting. Language can change the meaning of apparently stable terms. Platform architectures can alter observability. Research access can depend on gatekeepers whose roles are not visible in the final dataset. These contextual relations can be necessary for later researchers to understand what the preserved evidence was capable of showing.

A useful distinction separates four contextual layers. *Object context* concerns the institutional, social, technological, ecological, spatial, and historical conditions in which the target relation or process operated. *Evidence-production context* concerns the systems through which manifestations were recorded, classified, transmitted, or lost. *Research context* concerns access, field relations, instruments, team composition, methodological capabilities, and practical constraints. *Use context* concerns how findings entered later institutional, policy, organizational, or public processes when those uses can recursively affect the object or alter the meaning of the earlier claim.

Definition 9.214 (Contextual reconstruction envelope). A *contextual reconstruction envelope* is the documented set of historical, institutional, semantic, technological, evidential, and research conditions whose alteration could materially change the interpretation of preserved records, categories, models, or claims.

The term *envelope* emphasizes bounded relevance. The project need not preserve an exhaustive description of society at the time of research. It should identify the context needed to interpret the focal epistemic objects and the known dimensions along which context could matter. This bounded approach aligns preservation effort with inferential dependence.

Semantic context deserves particular attention. The same label can retain surface continuity while the relation it denotes changes. “Employment,” “ownership,” “household,” “platform,” “public,” “expert,” or “member” can be defined differently across institutions and periods. A record that uses one of these terms should therefore be interpretable under the category regime in which it was produced. Later researchers can introduce new analytical categories, but the historical meaning of the original label should remain separately recoverable.

Temporal context also constrains retrospective significance. Later consequences can make an earlier event newly important to inquiry. A technical choice can become

consequential after complementary infrastructure develops. An institutional classification can acquire power after being embedded in later administrative systems. A weak relation can become generative after a threshold is crossed. Preserving context allows later inquiry to recognize this significance without projecting the later outcome backward as though it had already been determined.

Research context can matter equally. A method unavailable at one time can later extract structure from preserved material. A field relation that limited access can explain why certain actor positions are weakly represented. A computational constraint can explain why a simplified model was selected. A contemporaneous ethical standard can explain why some data were intentionally not collected. Historical evaluation of the project benefits from knowing these conditions because present technical capacity should not be silently treated as an earlier option.

Proposition 9.215 (Context-linked historical intelligibility). *Preserved research materials support stronger historical re-epistemization when the contextual conditions that materially shaped their meaning, observability, production, or analytical use remain identifiable and separable from later contextual conditions.*

Proposition 9.215 connects context to versioning. Some contextual changes can be represented through new category versions; others through model changes, field-boundary changes, or revised historical interpretation. The following two subsections develop versioning for categories and models as explicit analytical objects.

9.15.5 Versioned Categories

Categories are central objects of historical re-epistemization because a change in classification can alter what the project observes, compares, and claims. The role of category versioning is to preserve the history of analytical and source categories across revisions. Its objective is to make semantic drift, boundary change, aggregation, disaggregation, and conceptual transformation visible rather than allowing a stable label to imply a stable object.

Category versioning applies to categories inherited from sources and categories introduced by researchers. Administrative datasets can revise industry codes, legal statuses, demographic classifications, organizational types, or geographic units. Archives can change cataloging rules. Researchers can revise coding categories after fieldwork reveals distinctions overlooked in the initial design. A model can require categories whose boundaries differ from those used in qualitative interpretation. Each change can affect comparability.

A category version should therefore contain more than a name. It can record the definition, inclusion and exclusion rules, operationalization, source, temporal scope, scale, relation to neighboring categories, and reason for revision. Where categories are used computationally, the version can also identify the code, mapping rule, or transformation that instantiated the category in data.

Definition 9.216 (Versioned analytical category). *A versioned analytical category is a category whose definition, scope, operationalization, evidential basis, temporal applicability, relation to earlier or later category versions, and revision rationale are explicitly recorded as part of the project's analytical lineage.*

Mappings among category versions can take several forms. One category can split into several. Several earlier categories can merge. Boundaries can shift without a simple split or merge. A category can be retained linguistically while its operationalization changes. A new category can identify a relation that the earlier scheme rendered invisible. Some mappings can therefore be many-to-one, one-to-many, partial, or non-invertible. The project should preserve that structure rather than forcing every revision into a one-to-one correspondence.

This point matters for longitudinal analysis. Suppose an organization type is reclassified midway through a time series. A naive merge can create an apparent change in prevalence that partly reflects classification. Conversely, refusing all mapping can prevent meaningful study of real continuity. Versioned categories allow the researcher to specify which comparisons remain defensible, which require bridging assumptions, and which are structurally ambiguous.

Historical semantics and present analytical categories should also remain distinguishable. Later theory may introduce a category that reveals a relation weakly named in the historical record. The category can be analytically productive while still being anachronistic if attributed directly to historical actors or institutions. A versioned architecture can preserve both levels: the source-native category regime and the later analytical category used for reinterpretation.

Definition 9.217 (Category bridge). A *category bridge* is an explicit, scope-bounded mapping among category versions that states which distinctions, memberships, or relational meanings are preserved, transformed, merged, split, or left incomparable when evidence is translated across category regimes.

A category bridge is an analytical claim rather than a clerical conversion. Its adequacy depends on the substantive relations the category is intended to represent. A bridge that is adequate for aggregate descriptive analysis can be inadequate for a relational or generative claim if the merged categories occupy different positions or support different mechanisms.

Category revision should therefore propagate downstream. If a category changes materially, the project should identify which datasets, representations, models, figures, tables, and claims depend on the earlier version. This creates a dependency graph for reanalysis. Later researchers can then determine whether a new category requires local recoding or a deeper reconstruction of the project's object.

Proposition 9.218 (Category-version continuity). *Longitudinal and historical claims gain re-epistemic integrity when changes in category definition or operationalization are versioned explicitly and when translations across versions state the distinctions preserved, transformed, or rendered incomparable.*

Proposition 9.218 prevents category stability from becoming an implicit ontological assumption. Categories can support continuity where justified while leaving room for historical transformation of the relations they represent. The same discipline applies to formal and computational models, which combine categories with structure, assumptions, parameters, and data dependencies.

9.15.6 Versioned Models

Model versioning preserves the analytical states through which formal and computational reasoning evolves. Its role is to make model change historically reconstructible. Its objective is to distinguish parameter updates, structural revisions, category revisions, data changes, implementation changes, and purpose changes so that later investigators can determine why a result changed and which earlier results remain comparable.

A model version is more than a source-code commit. Formal models can exist without executable code, and computational models can produce different results under the same visible code when data, dependencies, randomization, numerical libraries, hardware behavior, or configuration files change. Conversely, code can change without materially changing the analytical model. Historical re-epistemization therefore requires a model state defined at the level of epistemic function.

Definition 9.219 (Versioned model state). A *versioned model state* is a time-indexed specification of a model's analytical purpose, categories, variables or state objects, structural relations, assumptions, parameterization, data dependencies, estimation or calibration procedure, computational or formal implementation where relevant, and claim-linked outputs.

The model state should identify what changed relative to the preceding materially relevant version. A parameter update differs from a structural revision. A re-coded category can alter model inputs without changing equations. A new dataset can change estimation while leaving the formal structure fixed. A revised objective can make an earlier output irrelevant even if the model remains technically reproducible. Versioning should capture these distinctions because each implies a different comparison.

Model versioning also benefits from linking to the alternative-model archive in Section 9.15.2. A model lineage can branch. One branch can explore a different mechanism, another a different scale, another a category revision, and another a different estimation strategy. Treating the lineage as a sequence with one inevitable successor can hide these alternatives. A branch-aware archive preserves the fact that model development often involves comparative exploration rather than linear improvement.

Assumption changes deserve explicit treatment. Some assumptions are mathematical conveniences; others encode substantive claims about actor behavior, relational structure, temporal stationarity, independence, observability, or institutional rules. A later version that relaxes one of these assumptions can alter the epistemic standing of the model. The version record should state whether the change affects the model's substantive interpretation, empirical confrontation, or only computational implementation.

Outputs should also remain linked to versions. Figures, tables, simulations, estimated coefficients, network structures, and scenario results can otherwise circulate after the model that generated them has changed. A persistent output identifier or clear provenance link allows later users to determine which model state produced the object and whether the result was later superseded, qualified, or retained.

Proposition 9.220 (Model-version attribution). A *model-derived claim remains historically interpretable when its generating model state, category and data dependencies,*

materially relevant assumptions, and subsequent revision relation can be reconstructed at the level needed to explain changes in the claim.

Proposition 9.220 prepares future reanalysis. The purpose of versioning is not to freeze earlier models as authoritative. It makes change attributable. A later model can improve on an earlier one while preserving enough lineage to show whether the improvement arose from new evidence, changed categories, altered structure, better computation, a different question, or a different evaluative criterion.

9.15.7 Future Reanalysis

Future reanalysis is the first active operation enabled by the preservation architecture. Its role is to allow later inquiry to recompute, reconstruct, or reassess an earlier analytical target using newly available evidence, revised measurements, improved methods, or corrected processing while keeping the relation to the earlier epistemic state explicit. Its objective is attribution: a later result should reveal what changed in the analysis and why that change matters for the earlier claim.

Reanalysis differs from simple rerunning. Re-executing an unchanged pipeline can test technical reproducibility, which is treated later in this chapter. Historical reanalysis can intentionally alter the pipeline. New archives can be added, measurement can improve, missing data can become recoverable, a more suitable method can become available, or a discovered processing error can require correction. The reanalysis remains historically connected to the earlier project because it specifies the earlier target and records the dimensions that were deliberately changed.

Definition 9.221 (Future reanalysis pathway). *A future reanalysis pathway is a documented procedure for reconstructing an earlier analytical target from a specified as-of epistemic state, introducing one or more explicit evidential, measurement, methodological, categorical, or model revisions, and comparing the resulting claim with its earlier formulation while preserving both states.*

The pathway begins by reconstructing the baseline. The future researcher identifies the relevant as-of state, verifies which records and versions are available, and recovers the original claim at the appropriate scope. This prevents the reanalysis from comparing a later result with an idealized memory of the earlier study.

The next step is to declare the revision set. A reanalysis can add evidence, replace a measurement instrument, alter a field boundary, revise a category bridge, change a model family, introduce a new method, or update an uncertainty treatment. Several changes can be necessary, yet their joint use should remain explicit. Where possible, staged reanalysis can help localize which revision generated which change in the conclusion.

Comparison should then occur at the level of the claim rather than at output identity alone. A new parameter estimate can differ while preserving the same directional or structural conclusion. A new historical source can alter timing while strengthening the broader mechanism. A revised category can make direct numerical comparison inappropriate while improving relational interpretation. The reanalysis record should therefore state whether the earlier claim is reproduced, strengthened, narrowed, widened, transformed, contradicted, or rendered incomparable under the re-

vised architecture.

Reanalysis should ordinarily fork rather than overwrite the historical state. The earlier analysis remains an epistemic object because it documents what could be warranted under its conditions. Correcting a clear computational error can justify retiring an earlier result for present use, but even then the error and correction history can remain important for understanding downstream citations, decisions, or model development.

New evidence creates a particularly important case. Later records can resolve an uncertainty that the earlier project documented accurately. The appropriate historical conclusion is then two-level: the earlier uncertainty was warranted given the evidence available at the time, and the later evidence supports a stronger claim. Treating the earlier uncertainty as a mistake would erase the temporal structure of warrant.

Proposition 9.222 (Fork-preserving reanalysis). *Future reanalysis supports stronger historical comparison when the earlier analytical state is preserved, the revision set is explicit, and changes in the resulting claim are attributed to identifiable changes in evidence, categories, methods, models, or scope rather than being absorbed into an overwritten project state.*

Proposition 9.222 also enables cumulative research. Several later reanalyses can branch from one earlier state and explore different revisions. Their results can then be compared without assuming that one chronological successor automatically dominates all alternatives. This produces a research lineage in which evidence and methods evolve while the history of their effects remains inspectable.

Future reanalysis remains bounded by preservation. Some earlier materials will be unavailable, restricted, degraded, or irreversibly transformed. The reanalysis should record these limits rather than simulate completeness. In some cases, a new analysis will be better treated as a related study rather than as a reanalysis because the original target cannot be reconstructed sufficiently. The historical re-epistemization plan makes that boundary easier to justify.

9.15.8 Future Reinterpretation

Future reinterpretation is the deeper operation with which the section closes. Its role is to reopen the meaning, category structure, question, or explanatory significance of an earlier research object when later historical conditions or conceptual resources make a different reconstruction warranted. Its objective is to permit conceptual development without erasing the historical semantics and epistemic conditions of the earlier inquiry. Reinterpretation can use the same records as reanalysis, but it need not preserve the earlier analytical object unchanged.

The distinction between reanalysis and reinterpretation is therefore structural. Reanalysis generally asks what happens to an earlier target claim when evidence or analytical procedures change. Reinterpretation can alter the target itself: what counts as the relevant relation, which category distinctions matter, how a historical event is situated, what downstream consequences reveal, or which normative and political questions become salient. The two operations can interact, yet they should remain distinguishable because their comparison burdens differ.

Definition 9.223 (Future reinterpretation pathway). A *future reinterpretation pathway* is a documented reconstruction of an earlier epistemic object under materially changed conceptual, historical, semantic, normative, or evidential conditions, in which the earlier category regime and warrant are preserved sufficiently to distinguish retrospective analytical insight from claims about what was knowable or meaningful in the earlier period.

A later category can reveal structure that the earlier project did not conceptualize. A newly recognized form of dependence can make old contracts or correspondence analytically salient. Later consequences can reveal that an apparently minor institutional choice became a generative bottleneck. Changes in public norms can make harms or exclusions visible that earlier inquiry treated as peripheral. New theoretical work can identify a mechanism family that reorganizes old evidence. These developments can justify reinterpretation without implying that the later category or significance already existed in fully articulated form at the earlier time.

The first discipline is dual preservation. The later inquiry should recover the earlier category and interpretive regime while stating the new analytical vocabulary separately. This allows a historical source to be read in its earlier semantic context and also interrogated through later concepts. Where translation is partial, the remainder should remain visible. A later category can cut across several earlier categories; an earlier institutional distinction can lack a present equivalent. Reinterpretation gains integrity by preserving such non-equivalence.

The second discipline concerns downstream significance. Later events can change which earlier relations deserve attention. They cannot by themselves establish that those later outcomes were inevitable. Reinterpretation should therefore distinguish retrospective salience from retrospective determination. An early design choice can become historically important because later systems build around it, while the earlier configuration may still have allowed several plausible trajectories.

The third discipline concerns normative development. Later evaluative frameworks can reveal burdens, exclusions, or forms of domination poorly articulated in the earlier project. Such reinterpretation can be legitimate and important. The project should nevertheless distinguish evaluation of an earlier arrangement under later principles from evidence that the earlier actors themselves recognized or organized the issue in those terms. The separation preserves both normative learning and historical specificity.

Interpretive plurality can reappear as well. A superseded interpretation preserved under Section 9.15.3 can become newly relevant after a category revision or evidential discovery. A previously weak model can become informative once new data make its mechanism testable. A historical context once treated as peripheral can become central. The preservation architecture enables these changes without granting automatic vindication to every earlier alternative. Each reopened interpretation still requires evidential and conceptual assessment under the new conditions.

Proposition 9.224 (Non-erasing historical reinterpretation). *Historical reinterpretation is strengthened when new categories, meanings, or explanatory structures are introduced through explicit comparison with the earlier epistemic state, preserving historically specific semantics and uncertainty while identifying which later conditions justify*

the revised interpretation.

Proposition 9.224 expresses the central discipline of the section. Re-epistemization is additive in historical depth even when it is revisionary in conclusion. It does not require the earlier account to remain correct. It requires the pathway from earlier to later warrant to remain intelligible.

The complete historical re-epistemization plan can therefore be understood as preservation of future epistemic option space. Records preserve evidential access. Alternative models preserve formal possibility. Superseded interpretations preserve interpretive lineage. Context preserves historical intelligibility. Versioned categories preserve semantic and classificatory change. Versioned models preserve analytical evolution. Future reanalysis enables explicit revision of an earlier target under changed evidence or method. Future reinterpretation enables deeper reconstruction when the target's meaning or conceptual organization changes. Together these components allow provisional closure to coexist with historical openness.

This architecture also creates a bridge to the remaining infrastructure of Chapter 9. Re-epistemization depends on how contemporary research tools search, transform, summarize, model, and preserve materials. Machine-assisted workflows can enlarge future reconstructive capacity while also multiplying hidden transformations and version dependencies. Section 254 therefore turns to AI-assisted research workflow, treating AI systems as components of an explicit research architecture whose search, synthesis, coding, modeling, and generative functions require provenance, role specification, verification, and human responsibility.

9.16 AI-Assisted Research Workflow

Section 9.15 extended integrated research design across historical time by preserving the conditions under which future researchers can reconstruct and reopen an earlier epistemic state. The present section turns to a contemporary source of both generative capacity and epistemic dependence: the incorporation of artificial-intelligence systems into research workflow. Its role is to translate the earlier praxis-level treatment of AI-assisted research into an operational project architecture. Its objective is to specify where AI can enlarge search, synthesis, coding, formalization, simulation, pattern discovery, critique, and theory revision while preserving evidential lineage, verification, dependency awareness, accountable judgment, and research agency. The section therefore proceeds from task-specific forms of assistance to the project-level controls through which machine contributions remain inspectable. The method is function-sensitive and provenance-centered: each AI operation is evaluated according to what enters it, what it produces, how that output can legitimately enter later inference, how it is verified, which dependencies condition it, and where consequential research judgment remains located.

The design problem differs from the broader question of whether AI can contribute to research. Earlier chapters have already treated AI systems as instruments, dialogic interfaces, computational infrastructures, and possible mediators of research praxis. Chapter 9 asks a narrower and more operational question: how should a concrete project organize AI participation so that expanded generative capacity does

not obscure the epistemic status of the resulting objects? An AI-generated search query, summary, code fragment, formal model, simulation configuration, candidate pattern, critique, or theoretical revision can each be useful. They do not enter the research architecture in the same way. Some are exploratory prompts to further inquiry. Some are transformations of source material. Some become analytical procedures. Some generate synthetic evidence conditional on assumptions. Some propose changes to the conceptual structure of the project. Their evidential and inferential status must therefore be assigned locally rather than inferred from the common label “AI-assisted.”

A second distinction concerns production and warrant. AI systems can increase the rate at which candidate representations are produced. This increase can widen the encounter surface of research by surfacing documents, analogies, anomalies, models, counterexamples, or formalizations that a researcher might not have generated unaided. Production of candidates, however, does not itself establish which candidates deserve epistemic uptake. The research workflow needs a conversion architecture through which machine-generated objects move, when warranted, from exploratory status into verified evidence, accepted code, validated model components, or theory-relevant arguments. This conversion is where source checking, model testing, contextual interpretation, methodological comparison, and accountable judgment become decisive.

A third distinction concerns automation depth. A project can use AI for a bounded operation while keeping the surrounding workflow largely unchanged, or it can construct chains in which machine outputs determine later retrieval, coding, model specification, simulation, and interpretation. Deep chaining can create efficiency and generative breadth, but it can also propagate an early error, hidden assumption, category distortion, or provider-specific behavior through many later stages. The appropriate unit of documentation is therefore frequently the workflow path rather than the isolated prompt or output.

Definition 9.225 (AI-assisted research workflow). An *AI-assisted research workflow* is a project-level arrangement in which one or more AI systems perform specified research operations while the project preserves sufficient information about inputs, outputs, transformations, verification, dependencies, and accountable decision points to reconstruct how machine participation affected consequential claims or research decisions.

Definition 9.225 places AI inside the same architecture already developed for data, representations, methods, models, uncertainty, and historical re-epistemization. The relevant design question is not whether an output was produced by a machine in the abstract. It is what epistemic function the operation performed and how later claims depend on it.

For that purpose, the workflow benefits from an operation-level record.

Definition 9.226 (AI operation record). An *AI operation record* is a proportionate record of an AI-assisted research operation containing the operation’s research purpose, relevant input lineage, system identity or service class where available, materially consequential instructions or configuration, produced output, assigned epistemic status, verification pathway, downstream dependencies, and human acceptance, re-

Table 9.7: AI-assisted operations within an integrated research workflow

Operation	Principal research role	Initial output status	Principal control before consequential uptake
Search	Expand or reorganize candidate source discovery	Retrieval lead or ranked candidate set	Source identity, corpus boundary, retrieval-path, and omission checks
Synthesis	Compress and compare distributed materials	Provisional secondary representation	Claim-level return to sources and preservation of disagreement
Coding	Transform materials into labels, variables, relations, or structured data	Derived analytical object	Codebook alignment, validation sample, error analysis, and source linkage
Formalization	Translate verbal or conceptual structure into formal representation	Candidate formal object	Semantic correspondence, assumption inspection, derivation or code verification
Simulation	Execute or help construct rule-based generative experiments	Conditional synthetic output	Model specification, parameter provenance, implementation checks, and sensitivity analysis
Pattern discovery	Surface candidate regularities, anomalies, clusters, or relations	Exploratory pattern candidate	Independent evidential testing and representation/boundary checks
Critique	Generate objections, alternatives, counterexamples, or stress tests	Diagnostic candidate	Relevance assessment and independent evaluation of the objection
Theory revision	Propose category, mechanism, scope, or structural changes	Candidate theoretical revision	Reconstruction against evidence, prior theory, alternatives, and revision consequences

vision, or rejection decision.

The record need not preserve every low-stakes conversational turn. Documentation should be proportionate to epistemic centrality, practical consequence, opacity, irreversibility, and dependence. A discarded wording suggestion can require little retention. A machine-generated classification that determines the analytical dataset, a formal derivation used in a theorem, or a code path that produces a principal empirical result requires substantially more.

Table 9.7 summarizes the principal operation classes developed below. It distinguishes their normal research role, the status that outputs should initially receive, and the principal control required before those outputs can support consequential inference.

The table assigns deliberately modest initial statuses to AI outputs. This does not diminish their usefulness. It protects the transition from generation to warrant. The following subsections develop each operation and then specify the cross-cutting architecture of judgment, verification, audit, dependency management, and research agency.

9.16.1 AI-Assisted Search

AI-assisted search enlarges the encounter surface of research by altering how a project discovers potentially relevant literature, archives, datasets, cases, code, concepts, and evidential traces. Semantic retrieval, multilingual query expansion, similarity search, entity linking, conversational search, and generated search strategies can expose materials that would remain difficult to locate through a single keyword vocabulary. The methodological value of this expansion is greatest when retrieval remains connected to source identity and corpus conditions.

Search assistance should therefore be designed around a distinction between *discovery* and *coverage*. A system can discover highly relevant materials without establishing that the searched corpus is comprehensive. Ranking can produce a persuasive sequence of results while hiding what repositories were excluded, which languages were weakly represented, which documents were inaccessible, or which records were ranked below a retrieval threshold. High retrieval fluency can thus coexist with uncertain corpus coverage.

Definition 9.227 (AI-assisted search envelope). An *AI-assisted search envelope* records the repositories, corpora, interfaces, languages, time ranges, query or prompting strategies, ranking or retrieval mechanisms where known, inclusion decisions, and known access limitations that condition a machine-assisted source search.

The search envelope extends the data-provenance architecture developed earlier in this chapter. It also makes negative search results interpretable. Failure to retrieve a source can reflect substantive absence, incomplete digitization, ranking behavior, access restrictions, metadata weakness, translation failure, or a poorly specified query. The workflow should avoid converting non-retrieval directly into evidence of non-existence.

AI-assisted search can also operate recursively. Retrieved sources generate new entities, terms, citations, institutions, periods, or comparison cases; these become inputs to later search. Such recursion can be highly generative, but it can create path dependence. An early cluster of retrieved sources can shape the vocabulary used for subsequent retrieval and thereby narrow what later becomes visible. Periodic search diversification is therefore useful: alternative terminology, languages, disciplinary vocabularies, repositories, and seed documents can test whether the current retrieval trajectory has become overly self-reinforcing.

Proposition 9.228 (Search-provenance discipline). *Where AI-assisted search materially shapes the evidential corpus, the project should preserve enough information about source identity, search scope, retrieval conditions, and iterative query development to distinguish discovery success from corpus completeness and substantive absence from retrieval failure.*

Proposition 9.228 is especially important when later synthesis depends heavily on the retrieved set. Search bias can otherwise become synthesis bias while disappearing from view.

9.16.2 AI-Assisted Synthesis

AI-assisted synthesis compresses distributed materials into a representation that can be compared, navigated, or interrogated more efficiently. It can summarize documents, extract claims, compare positions, organize evidence by theme, reconstruct timelines, identify recurring concepts, or generate candidate maps of disagreement. The research benefit lies in increased navigability across large corpora. The epistemic risk lies in compression that silently erases provenance, qualification, minority positions, temporal change, or differences in evidential status.

Synthesis should therefore remain source-returnable. A consequential synthe-

sized statement should be traceable back to the materials from which it was produced. The project should distinguish direct quotation, source-supported paraphrase, generated inference, cross-source aggregation, and machine-proposed interpretation. These operations can appear equally fluent in a generated summary while carrying different evidential burdens.

Definition 9.229 (Source-returnable synthesis). A *source-returnable synthesis* is an AI-assisted secondary representation whose consequential claims can be traced to identified underlying materials together with sufficient contextual information to inspect whether the synthesis preserves their meaning, disagreement, scope, and evidential status.

Source returnability also protects historical and interpretive plurality. If several records use the same term differently, a compressed synthesis should preserve that difference when it matters to the argument. If one source reports an event and another interprets its significance, synthesis should not convert them into equivalent evidence. If a literature contains unresolved disagreement, generated consensus language should not erase it.

The synthesis stage is a useful point for deliberate adversarial prompting or alternative summarization. A project can request separate syntheses by period, method, theoretical tradition, evidential strength, or source type; it can ask the system to identify contradictions, missing perspectives, or claims supported by only one source. Such operations do not replace reading. They make the compression process itself more inspectable and can reveal where manual return to the corpus is most important.

Proposition 9.230 (Compression-provenance preservation). *The stronger the inferential role assigned to an AI-assisted synthesis, the more completely the workflow should preserve claim-level source returnability and distinctions among source report, source interpretation, cross-source aggregation, and machine-generated inference.*

This proposition prevents synthesis from becoming an unmarked evidential layer between the researcher and the underlying materials.

9.16.3 AI-Assisted Coding

AI-assisted coding transforms relatively unstructured materials into labels, variables, entities, relations, events, categories, annotations, or other structured analytical objects. It can accelerate qualitative coding, document classification, named-entity extraction, relation extraction, transcription cleanup, multilingual normalization, image annotation, and conversion of narrative records into event or network data. Coding is therefore a particularly important interface between manifestation and later formal or empirical analysis.

The central design requirement is to preserve the distinction between the source material and the derived coding layer. A generated label is not identical to the relation, event, intention, or category it is intended to represent. Its adequacy depends on the codebook, context, model behavior, ambiguity structure, and validation process. This is particularly important for relational research, where an automated system can infer an edge from co-occurrence, linguistic similarity, or a classification rule

even when the substantive relation remains uncertain.

Definition 9.231 (AI-assisted coding lineage). An *AI-assisted coding lineage* links each consequential derived code, category, event, entity, or relation to its source material, coding instruction or rule, relevant system or model state, validation status, human revision where applicable, and downstream analytical use.

Coding workflows benefit from explicit validation design. Depending on the task, this can include manually reviewed samples, double coding, stratified error analysis, disagreement analysis, calibration against known cases, tests across language or subgroup differences, and inspection of uncertain or low-confidence outputs. Aggregate accuracy alone can be insufficient when error is systematically concentrated in rare relations, historically marginal categories, minority languages, or precisely the cases most important to the research question.

AI coding can also reshape categories during inquiry. Repeated ambiguous cases may reveal that the existing codebook merges distinct relations or divides a historically continuous category. The appropriate response can be codebook revision rather than forcing the data into the initial scheme. Such revision should be versioned so that earlier and later coded states remain distinguishable.

Proposition 9.232 (Derived-code evidential discipline). *AI-generated coding can support consequential analysis when the project preserves source linkage, category definitions, validation evidence, error structure, and category-version history sufficiently to distinguish properties of the target material from properties of the coding procedure.*

The proposition aligns coding with the chapter's broader architecture of representation loss and historical re-epistemization.

9.16.4 AI-Assisted Formalization

AI-assisted formalization translates conceptual or verbal structure into mathematical notation, logical relations, diagrams, algorithms, computational models, proofs, or executable code. It can also work in the opposite direction by explaining a formal expression, exposing hidden assumptions, proposing test cases, or comparing alternative representations. These capabilities can reduce the practical cost of trying multiple formalizations before deciding which one preserves the distinctions required by the question.

The principal epistemic risk is semantic drift during translation. A fluent formal object can look precise even when it encodes a stronger equivalence, independence assumption, metric structure, causal direction, stationarity condition, or optimization criterion than the original concept supports. Formal correctness and conceptual adequacy are separate dimensions. A proof can be valid relative to premises that are substantively inappropriate; executable code can implement a model faithfully while the model misrepresents the target relation.

Definition 9.233 (Formalization correspondence record). A *formalization correspondence record* identifies the conceptual distinctions a formal representation is intended to preserve, the assumptions introduced during formalization, the elements compressed or omitted, the formal checks performed, and the empirical or interpretive pathway through which the representation reconnects to the research

object.

AI assistance can be especially useful for adversarial formalization. A researcher can request several candidate models under different assumptions, ask for counterexamples to an apparent theorem, generate dimensional or boundary checks, compare alternative state spaces, or produce executable tests for limiting cases. The output should then enter ordinary mathematical, computational, or substantive verification. Machine fluency does not exempt a derivation from proof checking or code from testing.

Proposition 9.234 (Dual verification of AI formalization). *Consequential AI-assisted formalization should be evaluated along both formal and semantic dimensions: the representation should be checked for mathematical or computational correctness and separately for correspondence with the concepts, evidence, and scope it is intended to represent.*

This dual requirement prevents technical correctness from being mistaken for substantive adequacy.

9.16.5 AI-Assisted Simulation

AI can assist simulation at several points: proposing model structure, generating code, calibrating or exploring parameters, constructing agents, producing synthetic scenarios, analyzing simulation output, or adaptively selecting new runs. In generative relational research, these capacities can widen the range of mechanism configurations and trajectory spaces that can be explored within a feasible research budget.

Simulation outputs remain conditional on the represented rules, initial conditions, boundary conditions, parameterization, stochastic structure, and implementation. AI assistance adds further conditionality because some of these components may themselves be generated or modified by a model. The workflow should preserve which elements were researcher-specified, data-estimated, AI-proposed, automatically optimized, or inherited from prior code.

Definition 9.235 (AI-assisted simulation provenance). *AI-assisted simulation provenance* is the lineage connecting a simulation result to its model specification, code state, data or calibration inputs, initial and boundary conditions, parameter choices, stochastic controls, AI-generated or AI-modified components, execution environment, and analysis procedure.

AI can also create an illusion of model exploration by generating many scenarios within a narrow model family. Large numbers of runs do not substitute for structural alternatives. A robust workflow distinguishes parameter exploration from mechanism exploration, model-family comparison, boundary variation, and representation change. This distinction connects directly to the model–evidence dialogue of Section 9.11 and the sensitivity architecture of Section 9.12.

Adaptive simulation introduces an additional issue. If an AI system uses early outputs to choose later experiments, the sequence of runs becomes part of the inferential history. Preserving only the final selected simulations can hide the search process that led to them. The workflow should therefore retain consequential adaptive-selection logic or enough intermediate states to reconstruct why particular regions

of the simulation space received attention.

Proposition 9.236 (Simulation-condition visibility). *An AI-assisted simulation result should inherit only the evidential status warranted by its model conditions, implementation checks, calibration pathway, and comparison with relevant empirical or historical evidence; increased automation or run volume does not by itself strengthen that status.*

9.16.6 AI-Assisted Pattern Discovery

AI-assisted pattern discovery uses computational systems to surface candidate regularities that may be difficult to identify through unaided inspection. Examples include clusters, anomalies, temporal motifs, relational structures, latent dimensions, textual associations, image features, sequence patterns, or cross-modal correspondences. Within GRE, such outputs can be especially generative because they can make previously unnoticed relations or transitions available for subsequent inquiry.

A discovered pattern should initially be treated as a candidate manifestation rather than as a settled relational or generative fact. The pattern can arise from substantive structure, sampling, preprocessing, representation choice, embedding geometry, model inductive bias, missingness, boundary selection, or chance. The workflow therefore needs a pattern-to-inquiry transition in which discovery is followed by independent tests, alternative representations, contextual reconstruction, or targeted data collection.

Definition 9.237 (AI-assisted pattern candidate). *An AI-assisted pattern candidate is a computationally surfaced regularity, anomaly, grouping, association, or structural feature whose substantive interpretation remains provisional until the project evaluates its dependence on data construction, representation, method, boundary, scale, and independent evidence.*

Pattern discovery can fruitfully interact with contingent encounter and aesthetic judgment. An unusual configuration can first register as salient before the researcher can state why it matters. AI enlarges the number of such encounters. This increases, rather than decreases, the importance of selective judgment because the project can now produce more candidate anomalies than it can investigate deeply.

One useful design is a staged pattern pipeline. Discovery occurs on one representation or data subset; stability is examined under alternative preprocessing or representations; substantive meaning is tested through historical, qualitative, relational, or domain-specific inquiry; and only then does the pattern enter a stronger explanatory claim. The exact stages vary by project, but the separation between discovery and warrant should remain explicit.

Proposition 9.238 (Discovery-to-warrant separation). *AI-assisted pattern discovery can legitimately reorganize research attention before the surfaced pattern has explanatory status, provided that later inference distinguishes computational salience from independently supported relational, causal, historical, or generative interpretation.*

9.16.7 AI-Assisted Critique

AI-assisted critique uses a system to generate objections, counterexamples, missing assumptions, alternative explanations, boundary cases, rival mechanisms, adversar-

ial readings, or possible failures in a research design. Unlike synthesis, which compresses an existing material set, critique deliberately expands the space of possible challenge. Its value lies in lowering the cost of exposing a draft claim to repeated structured opposition before project closure.

Critique should be designed to avoid becoming a ritual of generic objections. A useful workflow assigns the system a specific diagnostic target: evidential sufficiency, category stability, causal identification, historical anachronism, scale mismatch, normative premise, formal inconsistency, model dependence, alternative mechanism, or transfer beyond the studied cases. Targeted critique can then be compared with the project's uncertainty and robustness records.

AI-generated objections themselves require evaluation. A system can propose a logically possible alternative that is irrelevant to the actual evidence, repeat a common disciplinary criticism that does not apply locally, or invent a factual counterexample. The workflow therefore treats critique as a candidate stress test rather than an authoritative verdict.

Definition 9.239 (AI-assisted critique set). An *AI-assisted critique set* is a documented collection of machine-generated objections or alternative interpretations associated with a specified target claim, together with their diagnostic category, evidential relevance, disposition, and any project revision they trigger.

Preserving the disposition of serious critiques is useful even when the project rejects them. Later evidence can strengthen an earlier objection; a new category system can make a previously weak alternative more plausible. The critique set can therefore feed the historical re-epistemization architecture of Section 9.15.

Proposition 9.240 (Critique-disposition traceability). *Where AI-assisted critique materially affects a consequential claim, the project should preserve the objection, its evaluation, and the resulting acceptance, rejection, qualification, or revision so that later readers can distinguish exposure to criticism from unrecorded post hoc defense.*

9.16.8 AI-Assisted Theory Revision

AI-assisted theory revision moves beyond local critique by proposing changes to categories, mechanisms, scope conditions, relations among propositions, formal structure, or the organization of the research question itself. Such assistance can be generative because a system can rapidly compare multiple formulations, search for analogies across literatures, expose tensions among sections, or propose alternative decompositions of a theoretical object.

The revision stage requires especially careful separation between novelty and adequacy. A theoretically interesting proposal can be weakly connected to the evidence; a highly coherent reformulation can erase a historically important distinction; a mathematically elegant model can overcompress the relational structure. Theory revision should therefore return recursively to the translation architecture developed in Section 9.3: concept, object, representation, evidence, method, inference, and claim should be reconsidered together when a proposed theoretical change reaches across several of these layers.

Definition 9.241 (AI-proposed theory revision). An *AI-proposed theory revision* is

a machine-generated candidate change to a project's concepts, categories, mechanisms, scope conditions, structural relations, or formal organization whose adoption remains conditional on reconstruction against evidence, prior theoretical commitments, alternatives, and the downstream consequences of the revision.

AI can contribute most productively when revision is comparative. Instead of asking for one improved theory, the workflow can request several competing revisions, identify what each preserves or sacrifices, and test them against cases where the current theory performs poorly. The result becomes a model of theoretical option space rather than a single machine-selected answer.

Revision provenance should record what problem the change was intended to solve. Without this information, later versions can appear simply superior while the original tension, empirical anomaly, or conceptual conflict disappears. Versioning therefore applies to theory as well as to data and models.

Proposition 9.242 (Theory-revision accountability). *AI-assisted theory revision should remain attributable to an identifiable theoretical problem, comparison set, evidential constraint, and accountable adoption decision; generated coherence alone does not provide sufficient reason for conceptual replacement.*

9.16.9 Human Research Judgment

The preceding operations can be delegated to varying degrees, but their outputs still enter a project whose questions, stakes, evidential standards, ethical obligations, and closure conditions require judgment. Human research judgment should therefore be specified positively rather than invoked as a residual category for whatever automation cannot yet perform. Its role is to organize accountable decisions about significance, adequacy, scope, responsibility, and commitment within the research field.

Several judgments are especially consequential. Researchers decide which problem deserves sustained attention, which sources or communities require direct engagement, when a machine-generated pattern is worth investigating, which category distinctions matter, what constitutes sufficient verification, whether an uncertainty is tolerable, whether a theoretical revision preserves the research object, and when a result is ready for publication or practical use. AI can provide reasons, comparisons, forecasts, critiques, or alternative formulations around each decision. The accountable decision nevertheless needs a location within human and institutional relations capable of receiving criticism and revising commitments.

Definition 9.243 (Accountable research judgment point). *An accountable research judgment point is a consequential stage in a research workflow at which identifiable researchers or responsible institutions accept, reject, qualify, or redirect a machine-assisted output in light of evidence, method, context, ethics, uncertainty, and downstream consequences.*

The workflow should identify judgment points in proportion to consequence rather than forcing manual approval of every computational micro-operation. Excessive manual checkpoints can create documentation without meaningful responsibility. The relevant question is where the project changes epistemic status or commitment: candidate source to included evidence, generated label to accepted

variable, exploratory pattern to reported finding, candidate formalization to operative model, simulated possibility to practical recommendation, or proposed theory revision to adopted conceptual structure.

Human judgment is itself fallible and socially conditioned. Preserving its role does not establish an epistemic hierarchy in which humans are automatically correct. It preserves contestability and responsibility. A decision can be criticized because its reasons, evidence, and accountable agents remain identifiable.

Proposition 9.244 (Judgment-location discipline). *An AI-assisted workflow should identify the consequential transitions at which research objects change epistemic status or practical commitment and should locate accountable human or institutional judgment at those transitions rather than treating machine generation as self-authorizing.*

9.16.10 Verification

Verification converts machine-assisted production into warranted research uptake. Its design should be role-sensitive because different AI operations fail in different ways. A bibliographic search requires source existence and relevance checks. A synthesis requires return to the source. A coding pipeline requires validation and error analysis. Formalization requires semantic and formal checking. Simulation requires implementation, parameter, and model checks. Pattern discovery requires independent confirmation. Critique requires relevance and factual assessment. Theory revision requires reconstruction against evidence and conceptual commitments.

A single generic instruction to “verify AI output” is therefore insufficient. The project needs a verification pathway matched to the operation’s epistemic function and consequence.

Definition 9.245 (Role-sensitive verification pathway). *A role-sensitive verification pathway is a planned sequence of checks selected according to the epistemic function, failure modes, consequence, opacity, and downstream dependence of an AI-assisted operation.*

Verification can involve direct source inspection, independent computation, unit and integration testing, replication with alternative models, manual coding samples, cross-method triangulation, historical contextualization, formal proof checking, sensitivity analysis, expert review, or empirical confrontation. Several forms can be combined when the operation sits near the center of the claim architecture.

The depth of verification should also increase when later operations depend strongly on an earlier AI output. A generated category system used only for exploratory reading carries one burden. The same category system used to code all data, define the state space of a model, and determine the final causal comparison carries a much greater burden because one upstream error propagates through the project.

Proposition 9.246 (Consequence-and-dependence verification). *The required depth of verification should increase with the epistemic centrality, practical consequence, opacity, irreversibility, and downstream dependency of the AI-assisted operation being verified.*

Verification should preserve failures as well as successes when they materially in-

fluenced design. Rejected generated references, unstable classifications, failed code, contradictory formalizations, or unconfirmed patterns can reveal the boundaries of a workflow and prevent later researchers from repeating the same path without context.

9.16.11 Audit Trail

An audit trail records how AI participation changed the research process. Its purpose differs from exhaustive conversational logging. The project needs enough lineage to reconstruct consequential transformations and decisions, while respecting privacy, contractual limits, data minimization, and the practical impossibility of retaining every transient computational state.

The AI operation record in Definition 9.226 provides the atomic unit. At project level, these records should be connected so that researchers can see when one machine output became the input to another operation. This is particularly important in agentic or chained workflows, where search results feed synthesis, synthesis proposes a codebook, coding creates a dataset, the dataset feeds a model, and the model's anomalies trigger further search. A final result can otherwise appear to have many independent computational supports even though they descend from one early machine-generated assumption.

Definition 9.247 (AI workflow audit trail). *An AI workflow audit trail is the linked project record that connects consequential AI operation records, human judgment points, verification steps, revisions, and downstream dependencies sufficiently to reconstruct how machine participation affected a research claim or decision.*

Audit should preserve status changes. A generated object can move from exploratory candidate to verified input, from accepted input to later rejected assumption, or from apparently minor transformation to a recognized source of sensitivity. Versioned status allows later researchers to reconstruct the project's as-of epistemic state rather than seeing only the final accepted objects.

Auditability also supports contestability. A reader or collaborator should be able to ask which claims depend materially on AI assistance, what kind of assistance occurred, how it was checked, and what alternatives were considered. The answer need not expose private data or proprietary internals that the project cannot lawfully disclose. It should make the relevant dependency explicit and record the resulting limitation.

Proposition 9.248 (Linked-audit sufficiency). *An AI audit trail is sufficient for research reconstruction when it preserves the consequential transformation and dependency structure of machine participation, including verification and judgment, even when every transient interaction cannot or should not be retained.*

This proportional approach prepares the fuller documentation architecture developed in the later sections on research documentation, reproducibility, and reusability without duplicating those tasks here.

9.16.12 Dependency Management

AI-assisted workflows depend on technical and institutional infrastructures whose behavior may change outside the project. Models are updated, APIs are retired, access policies change, prices shift, context limits differ, retrieval systems alter ranking, safety policies change, and proprietary services may provide limited version visibility. Open models also depend on software libraries, hardware, checkpoints, tokenizers, data pipelines, and local configuration. These dependencies can affect reproducibility, comparability, access equality, and historical reconstruction.

Dependency management begins by distinguishing substitutable convenience from epistemically consequential dependence. If an AI system improves wording after the substantive analysis is complete, later inability to access the same system may have little effect on the claim. If the system performed unique retrieval, coding, model construction, or classification for which the raw intermediate results were not preserved, the project can become difficult to reconstruct.

Definition 9.249 (AI dependency profile). *An AI dependency profile identifies the models, services, software, interfaces, computational environments, provider-controlled behaviors, access conditions, and stored intermediate outputs on which a consequential research operation depends, together with the expected effect of dependency loss or change on reconstruction and reuse.*

Projects can manage high dependence through several strategies: preserving raw inputs and consequential outputs, recording model or service versions where available, retaining prompts or configuration when materially relevant, storing executable code around the service interface, using stable interchange formats, testing alternative systems, retaining benchmark cases, or preserving enough intermediate artifacts for later reanalysis even when exact rerunning becomes impossible.

Dependency diversification can also reveal model-specific effects. If two systems produce materially different coding, synthesis, or critique under comparable instructions, the divergence becomes an object of sensitivity analysis rather than a nuisance to be hidden. Conversely, apparent agreement among several tools should be interpreted cautiously when they share training data, model families, retrieval indexes, providers, or upstream datasets. Nominal multiplicity need not imply epistemic independence.

Proposition 9.250 (Dependency visibility). *Where a research claim materially depends on an AI system or provider-controlled infrastructure, the project should record that dependence and preserve enough intermediate state to distinguish later failure of exact rerunning from loss of the evidential and inferential basis of the claim.*

Dependency management thus connects the present workflow to robustness, uncertainty, and historical re-epistemization. Technical change becomes one condition under which a later inquiry may need to reconstruct rather than exactly reproduce an earlier result.

9.16.13 Preservation of Research Agency

The final component concerns the generative structure of the research process itself. AI can reduce the cost of searching, summarizing, coding, formalizing, simulating,

criticizing, and drafting. These capacities can expand what a researcher is able to attempt. They can also reorganize attention, vocabulary, methodological choice, expectations of speed, and the perceived space of plausible questions. Research agency is preserved when this expanded capacity remains available for deliberate inquiry rather than allowing default system affordances to determine the project trajectory.

Research agency should not be equated with performing every task manually. Delegation can increase agency by freeing attention for field engagement, difficult reading, conceptual judgment, interpretation, or design. The relevant distinction concerns who or what shapes the option space and closure conditions of the project. If researchers cease to understand why a method was selected, cannot inspect the evidential path of a central claim, depend on generated categories they cannot contest, or accept theoretical revisions because the system repeatedly presents them as the most coherent options, practical control over the research trajectory can narrow even while output volume increases.

Definition 9.251 (Research-agency preservation). *Research-agency preservation is the maintenance of sufficient human and institutional capacity to formulate and revise questions, select and contest methods, inspect consequential evidence and transformations, reject machine-generated options, redirect the inquiry, and assume responsibility for closure despite substantial AI participation in research operations.*

Several design practices support this condition. Questions can be formulated before and after AI exploration and compared to identify machine-induced drift. Important methodological choices can be justified independently of tool availability. Periodic source-level reading can prevent the project from becoming dependent on generated summaries. Alternative representations can be constructed when one model or platform begins to dominate the analytical vocabulary. Researchers can preserve the ability to reproduce critical transformations without conversational context alone. Collaboration and review can introduce perspectives outside a single human–AI interaction loop.

Agency also includes the right to retain productive uncertainty. AI systems often respond to open questions by rapidly generating plausible closure: a summary, likely explanation, recommended method, formalization, or next step. In research, unresolved tension can itself be generative. A workflow should therefore permit researchers to defer synthesis, preserve incompatible interpretations, or continue exploratory reading when premature closure would erase distinctions that matter.

Proposition 9.252 (Agency-preserving AI integration). *AI integration preserves research agency when computational assistance expands the project’s generative and analytical option space while researchers retain practical capacity to understand consequential dependencies, contest generated representations, redirect inquiry, preserve warranted uncertainty, and make accountable closure decisions.*

Proposition 9.252 completes the workflow architecture by linking technical assistance to research-dominant praxis. AI can enlarge encounter, comparison, formalization, simulation, and critique while evidential status, verification, responsibility, and research direction remain reconstructible. Section 255 turns to research governance: authorship, attribution, stewardship, ethical review, contestability, conflicts of interest, and institutional accountability.

9.17 Research Governance

Section 9.16 specified how artificial-intelligence systems can participate in an integrated research workflow while preserving verification, dependency visibility, and research agency. The present section broadens the unit of design from workflow operations to the governance of the research project as a whole. Its role is to make explicit the relations through which authority, responsibility, credit, stewardship, ethical review, contestation, conflict management, and institutional answerability are organized. Its objective is to prevent a technically well-designed project from becoming epistemically or ethically opaque at the level of who may decide, who must verify, who can authorize access, who receives credit, who may challenge a consequential representation, and who bears duties of correction when the project changes or fails. The discussion proceeds through responsibility, authorship, attribution, data stewardship, model stewardship, ethical review, contestability, conflicts of interest, and institutional accountability. The method is relational and role-sensitive: governance is analyzed through the allocation of capacities, duties, permissions, review pathways, and correction mechanisms across persons, communities, institutions, and technical infrastructures.

Research governance is related to research ethics, research administration, and legal compliance, yet it is not exhausted by any one of them. Ethical principles can specify relevant values and protections. Administrative procedures can authorize access, expenditure, or institutional participation. Law can establish binding duties and constraints. Governance concerns how these and other requirements become organized within the actual relational architecture of a project. A project may possess an ethics approval and still lack a practicable route for correcting a harmful classification. It may have named principal investigators while leaving uncertainty about who is responsible for a model inherited from a collaborator. It may publish a detailed data-management plan while leaving downstream reuse decisions to an unspecified future actor. Governance therefore concerns the operational distribution of answerability as well as the existence of formal rules.

The need for governance becomes stronger as research becomes distributed. A single project can involve investigators, research assistants, participants, community partners, archives, data custodians, funders, software developers, model providers, institutional review bodies, journal editors, repositories, and AI systems. These actors do not contribute the same kind of work, possess the same authority, or bear the same form of responsibility. Governance should preserve those differences rather than compressing them into a generic category of “the research team.” Distributed production can be epistemically productive while also creating gaps through which responsibility, provenance, or correction pathways become difficult to locate.

Definition 9.253 (Research governance). *Research governance* is the project-level organization of authority, responsibility, recognition, stewardship, ethical review, contestability, conflict management, and institutional answerability through which consequential research operations and outputs can be authorized, inspected, challenged, revised, and corrected.

Definition 9.253 treats governance as part of research design. It is therefore relevant before a dispute, error, ethical incident, or publication occurs. Governance

determines which actors have the capacity to prevent, detect, respond to, and learn from such events. It also shapes ordinary epistemic operations by deciding who may access data, approve a category change, alter a model, assign authorship, release an artifact, or respond to a challenge.

A useful project-level representation is a governance map.

Definition 9.254 (Research governance map). A *research governance map* identifies the principal governance objects of a project, the actors or institutions with relevant authority or duties, the decisions for which they are answerable, the review and contestation pathways available, and the escalation or correction mechanisms that apply when responsibilities overlap or fail.

The map need not become an elaborate bureaucracy for a small project. Its granularity should follow the project's consequence, scale, duration, heterogeneity, data sensitivity, infrastructural dependence, and distribution of authority. A solo theoretical project can require only a modest governance record. A longitudinal, multi-institutional, data-intensive project involving vulnerable participants, consequential classifications, or reusable computational infrastructure can require substantially more explicit allocation.

Table 9.8 summarizes the principal governance domains developed below. The table distinguishes the object being governed, the central design concern, the project mechanism through which governance can be made operational, and a characteristic failure that the mechanism is intended to prevent.

The domains in Table 9.8 interact. Authorship can affect responsibility; data stewardship can determine whether contestation is possible; conflicts of interest can shape model selection; institutional incentives can influence publication, correction, or disclosure. The aim of governance is therefore not to create isolated checklists. It is to preserve a sufficiently coherent allocation of authority and answerability across the relations through which research is produced and circulated.

9.17.1 Responsibility

Responsibility is the foundational governance relation because the remaining domains presuppose that some actor or institution can be called upon to verify, authorize, explain, repair, preserve, or correct consequential research operations. In distributed projects, however, responsibility rarely coincides with one person's total control. One researcher may design the study, another may collect data, a repository may govern access, a software provider may control a model dependency, and an institution may authorize dissemination. The design task is therefore to allocate responsibility without pretending that every participant possesses equivalent authority or causal influence.

Responsibility should be distinguished from blame. Governance is primarily prospective and operational: it asks which duties exist before an adverse outcome occurs and which actors have the capacity to discharge them. Retrospective accountability can become necessary after error or harm, but a project that defines responsibility only after failure has already lost an important preventive function. Prospective allocation clarifies who checks a result, who may approve a release, who

Table 9.8: Governance domains within an integrated research project

Governance domain	Principal design concern	Project mechanism	Characteristic governance failure
Responsibility	Allocation of duties for verification, authorization, care, disclosure, correction, and consequence management	Responsibility allocation and escalation map	Diffusion of responsibility through distributed production
Authorship	Assignment of authorship in relation to substantive contribution, intellectual agency, approval, and answerability	Authorship assignment record with revision procedure	Credit or authority detached from actual contribution and accountability
Attribution	Recognition and provenance of contributions that do not map cleanly onto authorship	Contribution and attribution map	Erasure, inflated credit, or loss of intellectual and material lineage
Data stewardship	Governance of collection, access, transformation, security, retention, transfer, and reuse	Data stewardship plan and custody record	Data access or reuse detached from permissions, provenance, or protection duties
Model stewardship	Governance of model meaning, versions, assumptions, implementation, access, maintenance, and downstream use	Model stewardship record and version authority	Model drift, untraceable modification, or reuse outside warranted scope
Ethical review	Recurrent assessment of foreseeable harms, protections, relations, and changed project conditions	Review pathway with defined trigger conditions	Ethical approval treated as a one-time substitute for continuing judgment
Contestability	Practical capacity to challenge consequential claims, categories, models, and representations	Contestability pathway with response and correction procedures	Public output without an effective route of review or correction
Conflict of interest	Identification and management of interests or dependencies that can distort judgment or its appearance	Conflict-of-interest profile and management plan	Material interests disclosed incompletely or left unmanaged
Institutional accountability	Alignment of organizational authority, resources, incentives, and correction duties with project consequences	Institutional accountability chain and escalation pathway	Institutions control consequential conditions while answerability remains indeterminate

monitors an ethical condition, who preserves a record, and who initiates correction when a material problem is identified.

Definition 9.255 (Research responsibility allocation). *A research responsibility allocation assigns materially relevant duties of verification, authorization, care, disclosure, preservation, monitoring, correction, and consequence management to actors or institutions that possess sufficient authority, access, competence, or control to perform those duties, while recording shared and overlapping responsibilities where they materially affect the project.*

This definition rejects two opposite simplifications. Responsibility should not be concentrated automatically in the most senior named researcher when other actors control consequential operations that the senior researcher cannot inspect. It should also not be diffused so broadly that each participant can assume that another person or institution will act. Shared responsibility can be appropriate, but it requires identifiable duties and pathways for coordination.

A useful governance record separates at least four dimensions. The first is *decision authority*: who may approve a consequential action. The second is *epistemic duty*: who must verify or interpret the basis of that action. The third is *operational duty*: who must execute, monitor, preserve, or communicate it. The fourth is *correction duty*: who must respond when the action is later shown to be defective or harmful.

These dimensions can be assigned to different actors. Their separation prevents approval authority from being mistaken for technical expertise and technical execution from being mistaken for final accountability.

Responsibility also changes over time. A doctoral researcher may initially control a dataset, a laboratory may later become its custodian, and a repository can acquire long-term preservation duties after project closure. A model may move from an exploratory notebook into a shared package maintained by another team. Governance should therefore version responsibility when custody, authority, or project phase changes. Historical reconstructibility depends partly on knowing who could make which decisions at a given time.

Proposition 9.256 (Responsibility traceability). *Where a research operation can materially affect evidential warrant, participant interests, public representation, reusable infrastructure, or downstream action, the project should preserve a practicable path from that operation to identifiable duties of authorization, verification, monitoring, and correction proportionate to the operation's consequence and persistence.*

Responsibility traceability does not imply that every outcome can be assigned to one actor. Some failures arise from interactions among procedures, infrastructures, incentives, and incomplete knowledge. Governance remains useful in these cases because it can identify who had the capacity to detect or mitigate a failure, who controlled relevant conditions, and what institutional arrangements should change. The aim is accountable coordination rather than retrospective simplification.

9.17.2 Authorship

Authorship governs a particular conjunction of intellectual recognition and public answerability. In a complex research project, visible authorship can influence reputation, authority, career opportunity, and the perceived source of a claim. It can also indicate who has taken responsibility for the integrity of a published work. These functions make authorship more than a ceremonial ordering of names. A defensible assignment should reflect the substantive organization of contribution and the capacity of named authors to understand, approve, and answer for the work within their roles.

Contribution alone does not always settle authorship. A technician, translator, data curator, community advisor, software engineer, or infrastructure provider can make an indispensable contribution whose appropriate recognition may differ from authorship. Conversely, status, supervision, funding authority, or institutional seniority can create pressure for authorship even when substantive participation is limited. Governance should therefore separate the question of what contribution occurred from the question of which contribution and responsibility configuration warrants authorship in the specific scholarly context.

Definition 9.257 (Authorship assignment record). *An authorship assignment record is a project record that links proposed authorship to substantive intellectual or research contributions, participation in relevant review and approval, and the forms of answerability that named authors accept for the resulting work, together with a procedure for revising the assignment as contributions change.*

The record is especially useful in long projects because contribution trajectories change. A collaborator can become central after developing a new model or conducting a major reinterpretation. Another contributor can leave before final analysis and be unable to review later claims. Early authorship expectations can therefore be treated as provisional governance arrangements rather than immutable promises. Revision should be reasoned, documented, and communicated before publication where feasible.

Authorship also interacts with distributed expertise. One author may be able to verify a formal derivation while another is responsible for archival interpretation or field access. It can be unrealistic to expect every author to reproduce every specialized operation personally. Collective authorship becomes defensible when the project makes the distribution of expertise and responsibility sufficiently clear that the work as a whole has an accountable review structure. This is stronger than assuming that co-authorship creates undifferentiated responsibility for every technical detail.

AI assistance sharpens this distinction between contribution and authorship. A system can generate text, code, analyses, candidate interpretations, or formal structures that materially shape a manuscript. Within the governance architecture developed here, such participation belongs in provenance and attribution because it affects how the work was produced. Authorship, by contrast, is tied to the ability to exercise research judgment, approve the final work, receive contestation, and participate in responsibility and correction. Where an AI system lacks the institutional and practical standing required for those functions, machine contribution should remain visible without being converted automatically into authorship.

Proposition 9.258 (Authorship–answerability alignment). *Authorship assignment is strongest when visible scholarly credit remains aligned with substantive contribution, informed approval, and a practicable capacity to participate in explanation, correction, and response to serious challenge within the author’s area of responsibility.*

The proposition leaves room for disciplinary variation in authorship conventions. The governance requirement is not a universal ordering rule. It is that a project can explain how authorship relates to contribution and answerability and can revise the allocation when the actual research trajectory materially departs from the initial plan.

9.17.3 Attribution

Attribution is broader than authorship. Research depends on conceptual, material, technical, linguistic, institutional, and relational contributions that can disappear when credit is represented only through an author list. Attribution governs how these contributions remain visible and how later users can reconstruct the lineage of ideas, evidence, data, code, models, translations, classifications, community knowledge, infrastructure, and machine assistance.

The epistemic role of attribution is as important as its distributive role. A reader who knows that a category originated in participant language, that a dataset was curated by a specific archive, that a model was adapted from an earlier implementation, or that a synthesis was substantially AI-assisted can interpret the resulting work dif-

ferently. Attribution can therefore preserve information about origin and transformation, not only allocate recognition.

Definition 9.259 (Research attribution map). A *research attribution map* links consequential intellectual, evidential, technical, linguistic, infrastructural, community, and machine-assisted contributions to their sources and transformation roles in forms of acknowledgment, citation, provenance, contributor description, or other recognition appropriate to the project.

A good attribution map avoids two distortions. The first is *erasure*: contributions become invisible because they do not fit established authorship categories or because their origin is absorbed into a later representation. The second is *inflation*: incidental support receives a level of intellectual credit that obscures the actual source of the work. Attribution should therefore describe contribution type with enough specificity that recognition remains informative.

Community and participant contributions require particular care. A research subject can provide information without seeking public identification. A community can shape categories or research questions collectively even when individual naming is impossible or undesirable. Traditional, local, or institutional knowledge can also have governance conditions that differ from ordinary academic citation. Attribution should therefore be coordinated with consent, confidentiality, data stewardship, and relevant community expectations. Recognition is not automatically beneficial when it exposes persons or groups to unwanted visibility.

Technical attribution should likewise preserve dependency. Code libraries, pre-trained models, datasets, repositories, instruments, and infrastructure can materially condition results. Their recognition can help later investigators reconstruct the project's operational lineage. AI attribution belongs in this category when a system performed consequential search, synthesis, coding, formalization, simulation, critique, or drafting. The AI operation records of Section 9.16 provide a more detailed internal lineage; public attribution can then be calibrated to the significance of that participation and the disclosure norms of the research context.

Proposition 9.260 (Attribution-provenance coupling). *Where a contribution materially shapes the content, evidential basis, representation, or reproducibility of a research output, attribution should preserve enough information about the contribution's origin and role to support both fair recognition and later reconstruction, subject to legitimate privacy, confidentiality, and safety constraints.*

Authorship and attribution can therefore diverge without conflict. A project can have a small author group and a much wider attributed contribution network. Making that network visible is particularly important for cumulative research because future investigators often need to know where a concept, dataset, transformation, or technical dependency entered the project.

9.17.4 Data Stewardship

Data stewardship governs the continuing relation between a project and the evidential materials it collects, receives, derives, links, transforms, stores, shares, or preserves. The term *stewardship* emphasizes custodial and relational duties. Possession

of a dataset does not by itself settle who may use it, how long it should be retained, what transformations are permissible, which protections remain active, or whether later reuse is compatible with the conditions under which the data were generated.

The data architecture developed earlier in Chapter 9 identified provenance, transformation, access, and preservation as components of research design. Stewardship adds authority and duty. It asks who can approve access, who maintains security, who monitors changes in sensitivity, who decides whether linkage is permissible, who manages corrections, who responds to participant or community concerns, and who governs transfer when the project or institution changes.

Definition 9.261 (Data stewardship plan). A *data stewardship plan* is the governance arrangement that assigns authority and duties for data acquisition, access, transformation, linkage, protection, retention, correction, transfer, preservation, deletion, and reuse across the lifecycle of a research project, together with the permissions and constraints that condition those operations.

Stewardship should distinguish raw or source-near materials from derived data. A cleaned dataset, coded corpus, relational graph, embedding, feature matrix, or synthetic derivative can carry different risks and reuse possibilities from the material from which it was produced. Derivation can reduce some risks while creating others. For example, an apparently de-identified relational dataset can become identifying when linked with external information. A synthetic representation can reproduce sensitive structural properties even when direct records are absent. Governance should therefore follow transformations rather than assuming that sensitivity disappears once a format changes.

Access also has multiple levels. Some project members may need identifiable source data; others may require only derived variables. External researchers can sometimes work through controlled access while public users receive a more restricted release. Differential access can preserve both research utility and legitimate protection. The relevant governance question is whether access conditions correspond to purpose, risk, authorization, and the ability to enforce downstream duties.

Historical re-epistemization creates a genuine stewardship tension. Section 9.15 argued for preserving records sufficient for future reinterpretation, while privacy, confidentiality, participant expectations, community governance, security, or contractual conditions can justify restricted retention or deletion. The project should therefore preserve epistemic optionality within legitimate stewardship constraints. In some cases this can mean retaining metadata, transformation histories, category definitions, or aggregate structures after source-level access has ended. In others, future reconstructibility may appropriately remain limited.

Definition 9.262 (Data custody record). A *data custody record* identifies, for a consequential dataset or data class, the current custodian, authorized access roles, governing permissions, principal transformations, retention or transfer conditions, and the pathway through which corrections, restrictions, or deletion decisions can be enacted.

Custody can move across time. A field team can collect data that later enter an institutional repository; a collaborator can transfer stewardship when leaving a project;

a community-governed dataset can remain under external control while researchers receive temporary access. The custody record preserves these transitions so that later users do not mistake possession of a copy for unrestricted authority.

Proposition 9.263 (Stewardship continuity across transformation). *Material data transformations, transfers, or changes of custodian should preserve the governance conditions that remain relevant to provenance, authorized use, protection, correction, and future reuse, with any change in those conditions explicitly justified and recorded.*

Data stewardship thus connects ethics, epistemology, and infrastructure. It protects persons and communities while also preserving the evidential lineage required for interpretation and correction.

9.17.5 Model Stewardship

Models can become durable research objects whose influence extends beyond the project that created them. Statistical models, simulations, formal mechanisms, relational maps, machine-learning systems, scoring procedures, and computational pipelines can be copied, adapted, calibrated to new data, embedded in software, or treated as inherited infrastructure. Model stewardship governs these trajectories by maintaining the relation between a model's operational form and the assumptions, evidence, semantics, scope, and responsibilities that make its use intelligible.

The model–evidence dialogue of Section 9.11 treated models as revisable representations that can change at parameter, structural, categorical, methodological, or theoretical levels. Stewardship adds the question of who may make these changes and how model continuity is preserved across them. A model can retain the same name while its data, parameters, code, categories, or intended use change materially. Governance should therefore distinguish nominal continuity from substantive model continuity.

Definition 9.264 (Model stewardship record). *A model stewardship record identifies the authority and duties associated with a consequential research model, including its conceptual target, version lineage, assumptions, implementation, data or calibration dependence, permitted modifications, validation or evaluation history, access conditions, known limitations, and procedures for correction, deprecation, transfer, or downstream reuse.*

Model stewardship begins before release. During development, it can identify who may merge changes, alter a category system, approve a parameter source, modify training data, or declare a version sufficiently stable for a particular research claim. These permissions can be lightweight in a small project and more formal in a shared codebase or multi-institutional model. The important point is that consequential modifications remain attributable to a reviewable process.

Stewardship also preserves model semantics. Executable code can survive after the meaning of variables, parameters, state transitions, training labels, or objective functions has become unclear. This produces a particularly dangerous form of reuse because technical operability can be mistaken for substantive validity. A stewardship record should therefore connect code and equations to the conceptual and evidential interpretation that justified them.

AI and machine-learning models introduce additional dependencies. A project may use a proprietary model whose weights, training data, or update history are partly inaccessible. Stewardship cannot create information that the project does not possess. It can, however, record the dependency, preserve consequential inputs and outputs, maintain evaluation cases, note version changes where observable, and state the resulting limitations. Where a provider-controlled update materially changes research output, the model dependency becomes part of the project's uncertainty and historical record.

Downstream transfer deserves separate attention. A model created for exploratory research can later be used for prediction, classification, allocation, or policy analysis under conditions that were absent from the original study. The original project may not control every later use, but it can reduce ambiguity by recording intended scope, evaluated domains, material limitations, and known failure conditions. Where the research team remains the maintainer or distributor, stewardship can also include version notices, correction pathways, and deprecation of materially defective releases.

Proposition 9.265 (Model stewardship continuity). *A consequential model should remain linked, across material revisions and transfers, to sufficient information about its semantics, evidence, assumptions, version state, evaluation history, and governance authority for later users to distinguish technical availability from warranted use.*

Model stewardship therefore complements data stewardship. Data governance preserves the conditions under which evidence can be accessed and reused; model governance preserves the conditions under which transformations of that evidence can be interpreted, revised, and responsibly carried forward.

9.17.6 Ethical Review

Ethical review governs the project's continuing examination of foreseeable harms, protections, power asymmetries, burdens, benefits, representation, consent or permission conditions, privacy, disclosure, and downstream consequences. Formal institutional review can be an important part of this architecture, particularly where human participation, sensitive data, or regulated procedures are involved. Integrated research design nevertheless requires a broader temporal view: ethically relevant conditions can change after an initial approval as questions, data linkages, models, collaborators, dissemination plans, or technologies evolve.

The governance problem is therefore one of review continuity. A project can begin with low-risk documentary analysis and later incorporate identifiable interviews. A dataset can acquire new sensitivity after linkage. An exploratory model can become consequential when an institution expresses interest in deployment. AI-assisted coding can introduce a new external service through which sensitive material passes. A public release can create exposure risks that were absent during analysis. These changes can require ethical reassessment even when the original design was appropriately reviewed.

Definition 9.266 (Research ethical review pathway). *A research ethical review pathway is the project arrangement through which ethically consequential design choices, material changes, emerging harms, participant or community concerns, and downstream uses can be identified, assessed, escalated to an appropriate reviewer or deci-*

sion body, and translated into continuation, modification, mitigation, restriction, or cessation decisions.

Ethical review should remain connected to the actual locus of expertise and affected interests. A centralized institutional body may be able to assess general risk while lacking detailed knowledge of a community, archive, technical system, or cultural context. Local collaborators, participants, data stewards, technical experts, or community governance bodies can therefore provide forms of ethical knowledge that complement formal review. Their contributions should enter a defined process rather than being treated as informal advice that disappears from the project record.

A useful design identifies *review triggers*. These are project changes or observations that warrant renewed ethical attention. Examples can include expansion to a new participant group, collection of a new data type, linkage that increases identifiability, changes in consent or permission conditions, discovery of unanticipated harm, adoption of a materially different model or AI provider, change in dissemination audience, or a proposed downstream use with greater consequence than the original research purpose. The precise triggers should follow the project's context rather than being treated as a universal list.

Definition 9.267 (Ethical review trigger). An *ethical review trigger* is a specified project change, new information, or emerging consequence whose material effect on risks, protections, permissions, power relations, or downstream use warrants renewed ethical assessment under the project's review pathway.

Ethical review and epistemic review interact without becoming identical. A method can be statistically strong while ethically inappropriate for the available data. A representation can be ethically cautious while evidentially weak. A participant preference can carry major ethical significance without determining a population-level empirical claim. Governance should preserve these distinctions so that ethical reasoning does not become a substitute for evidence and evidential strength does not erase duties of care.

Proposition 9.268 (Continuing ethical review). *Where a project undergoes a material change in participants, data, representation, technology, dissemination, or downstream consequence, ethical review should be capable of reopening the relevant decision rather than treating earlier approval as sufficient evidence that the changed configuration remains acceptable.*

Continuing review also supports historical re-epistemization. Later researchers can understand why a dataset was restricted, why a method was abandoned, or why a dissemination decision changed when ethical reasoning and trigger events remain reconstructible.

9.17.7 Contestability

Contestability turns research openness into a practical relation of challenge and response. Earlier chapters treated contestability as an epistemic condition under which consequential representations can be questioned by actors who possess relevant evidence, interpretation, or affected knowledge. Project governance must translate that condition into a pathway: who can raise a challenge, what information is available

for understanding the contested object, who reviews the challenge, how competing evidence is evaluated, and what forms of correction or response are possible.

Contestability differs from public visibility. A paper can be publicly accessible while its data are inaccessible, its model undocumented, its category construction opaque, or its authors unreachable. Conversely, a controlled-access project can be meaningfully contestable if affected actors and qualified reviewers have practicable channels to examine the relevant basis of a claim. The design target is therefore reviewability under appropriate access conditions rather than unrestricted disclosure of every research object.

Definition 9.269 (Project contestability pathway). A *project contestability pathway* is a defined process through which a relevant actor can identify a consequential research claim, category, dataset, model, representation, or decision; obtain sufficient information to formulate a materially grounded challenge; submit evidence or interpretation; receive reasoned review; and trigger correction, qualification, preservation of disagreement, or rejection of the challenge as warranted.

Different challenges require different reviewers. A coding error may require technical reanalysis. A category dispute may require interpretive and participant knowledge. A conflict over historical meaning can benefit from archival or domain expertise. An ethical concern can require a governance or ethics body with authority beyond the research team. A project should therefore avoid routing every challenge back to the same actor whose decision is contested, especially where power asymmetry or reputational interest is substantial.

Contestability should also be consequence-sensitive. An exploratory notebook used only inside a research team can support informal challenge. A published dataset, widely reused classification, high-impact model, or public claim about a vulnerable group can warrant stronger review and correction mechanisms. Persistence matters because a representation that continues to circulate can reproduce an error long after the original researchers have moved on.

A challenge does not receive automatic evidential priority merely because it is raised by an affected actor, a senior scholar, or a large number of critics. Governance should preserve meaningful access to review while maintaining standards of evidence and argument. This is where contestability and cross-method adjudication meet: a serious challenge can reopen the project's evidence, representation, method, model, or interpretation without predetermining the outcome of that reopening.

Correction itself has several forms. A factual error can be corrected directly. A model limitation can require qualification. A contested interpretation can warrant preservation of multiple readings. A dataset can require withdrawal or restricted access. A category can be versioned rather than silently overwritten. A claim can remain unchanged after a challenge when the review finds the counterevidence insufficient. The contestability record should preserve enough information to distinguish responsiveness from automatic concession.

Proposition 9.270 (Contestability with review consequence). A *consequential research output is meaningfully contestable when materially relevant challenges can reach a review process with sufficient authority and information to produce a reasoned response and, where warranted, an effective change in the research record, access*

condition, representation, or claim.

Contestability thereby becomes a governance mechanism of correction and future generativity. Challenges can expose distinctions, evidence, or harms that the original project did not recognize and can reopen lines of inquiry that apparent closure had suppressed.

9.17.8 Conflicts of Interest

Conflicts of interest arise when a secondary interest, dependence, obligation, or relational position can materially affect, or reasonably be understood to affect, judgment concerning the primary epistemic and ethical purposes of a research role. Financial interests are one important class, but research governance should also consider institutional, professional, intellectual, methodological, relational, political, infrastructural, and publication-related dependencies where they materially shape decisions.

The term *interest* should be interpreted broadly enough to capture structural incentives without treating every commitment as disqualifying. Researchers inevitably possess theoretical preferences, disciplinary identities, career incentives, institutional affiliations, and personal relations. Governance becomes relevant when an interest has a plausible pathway to influence a consequential decision and when ordinary critical reflection is insufficient to manage that pathway.

Definition 9.271 (Research conflict-of-interest profile). *A research conflict-of-interest profile identifies material financial, institutional, professional, intellectual, methodological, relational, infrastructural, or other dependencies that can influence consequential research judgment, together with the decisions they may affect, the disclosure required, and the management or independent review measures appropriate to the project's context.*

Conflicts can operate at different stages. A funder can influence problem selection. An institution can benefit from favorable evaluation. A researcher can have invested years in a theory whose rejection carries reputational cost. A model developer can evaluate a system they designed. A community partner can have strong interests in how findings are represented. A proprietary platform can create dependence on a provider whose commercial interests are partly aligned with a favorable assessment. These situations do not automatically invalidate research. They alter the governance conditions under which claims should be produced and evaluated.

Disclosure is one response, but disclosure alone can be insufficient. If an interest is likely to influence a high-consequence decision, management can include independent verification, separation of roles, additional methodological redundancy, external review, recusal from a specific decision, predefined decision criteria, preservation of alternative analyses, or transfer of authority to an actor with a different conflict profile. The appropriate mechanism depends on the severity, observability, and manageability of the conflict.

Intellectual conflicts deserve particular nuance. A researcher who developed a theory is well positioned to understand its structure and can also be motivated to preserve it. Eliminating such involvement would often destroy expertise. Governance can respond by increasing exposure to counterevidence, preserving serious alterna-

tive models, assigning adversarial review, or requiring explicit disposition of anomalies. The goal is to manage predictable pathways of bias while retaining valuable knowledge.

Institutional conflicts can be similarly distributed. A university can be both the employer of researchers and the entity responsible for investigating research misconduct. A repository can seek openness while also bearing privacy obligations. A journal can benefit from attention generated by a contested paper while controlling correction procedures. Governance should therefore identify where review authority and institutional interest coincide and whether additional independence is warranted.

Proposition 9.272 (Conflict-management proportionality). *Where an identifiable interest or dependency has a plausible pathway to influence a consequential research decision, governance should make the pathway visible and apply disclosure, separation of roles, independent review, redundancy, recusal, or other controls proportionate to the conflict's magnitude, opacity, and potential consequence.*

Conflict management should itself remain documented because later evidence can change how a prior interest is interpreted. A relationship initially regarded as minor can become material if the research output later enters a higher-consequence setting.

9.17.9 Institutional Accountability

Research projects operate within institutions that allocate resources, establish permissions, employ researchers, maintain repositories, purchase infrastructure, negotiate contracts, administer ethical review, evaluate careers, communicate with publics, and control many correction procedures. Institutional accountability concerns the relation between this organizational power and the duties that accompany it. A project can assign individual responsibilities carefully while remaining weakly governed if the institution controlling a critical condition has no practicable obligation to respond when that condition fails.

Institutional accountability should be distinguished from attributing every research outcome to the host institution. Institutions vary in their degree of control over specific operations. A university may control data infrastructure but not a journal's correction process. A funder may influence resource allocation but lack access to participant records. A commercial provider can control an AI service without controlling the project's interpretation of its output. Governance should therefore identify institutional responsibility through actual authority, dependence, and capacity rather than through organizational proximity alone.

Definition 9.273 (Institutional accountability chain). *An institutional accountability chain identifies the organizations that materially control or condition consequential research resources, permissions, infrastructures, incentives, review processes, or dissemination pathways, together with the duties, escalation routes, and correction capacities through which those organizations can be called upon to respond to failure, challenge, or changed conditions.*

Accountability chains are especially important in multi-institutional projects. Data can be held by one institution, analysis performed by another, funding provided by

a third, and publication controlled by a fourth. A participant or collaborator who encounters a serious problem can otherwise face a circular pattern in which each institution points to another actor as responsible. A governance map should therefore identify where an issue enters, who has authority to act, and how escalation proceeds when responsibility crosses organizational boundaries.

Institutional incentives also belong within accountability analysis. Promotion systems, grant deadlines, publication metrics, proprietary partnerships, prestige competition, and demands for rapid output can shape publication, release, correction, and communication decisions even when formal policies are sound. Governance can respond by making consequential pressures visible and creating countervailing review or preservation mechanisms.

Infrastructure creates another form of institutional power. Repositories shape access and retention; compute and AI providers condition model availability and behavior; journals and platforms influence visibility and correction. These dependencies can affect reproducibility, contestability, and historical reconstructibility and should therefore appear in the project governance architecture.

Proposition 9.274 (Authority–accountability correspondence). *Where an institution materially controls a research condition that can affect evidential integrity, participant protection, access, dissemination, correction, or long-term preservation, the governance architecture should identify a corresponding pathway through which that authority can be reviewed and called upon to respond within the scope of its actual control.*

The project can consolidate the preceding domains in a governance charter.

Definition 9.275 (Project governance charter). *A project governance charter is a proportionate, revisable statement that integrates the project’s responsibility allocations, authorship and attribution procedures, data and model stewardship, ethical review pathway, contestability mechanisms, conflict-of-interest management, and institutional accountability chain, together with the conditions under which these arrangements are reviewed or revised.*

The charter is an architectural object rather than a required document format. It may consist of concise records in a small project or formal agreements, role matrices, and review procedures in a large collaboration. Its purpose is to preserve correspondence between epistemic structure and the organization of authority and answerability.

Governance remains historically revisable. Roles change, data move, models become infrastructure, conflicts emerge, and outputs acquire new downstream uses. Periodic review should therefore focus on material changes in authority, dependence, consequence, and correction capacity.

Proposition 9.276 (Governance revision under project change). *When a research project undergoes a material change in authority, stewardship, institutional dependence, participant relation, model use, dissemination, or downstream consequence, its governance arrangements should be reassessed so that responsibility, review, and correction pathways remain aligned with the changed research configuration.*

Research governance supplies the authority and answerability needed to maintain the preceding project architectures. Section 256 develops the documentation through which governance arrangements and epistemic decisions remain reconstructible.

9.18 Research Documentation

Section 9.17 developed the governance architecture through which authority, responsibility, stewardship, review, contestability, and institutional accountability are allocated within a research project. The present section develops the documentary architecture through which those arrangements and the epistemic history of the project remain reconstructible. Its role is to preserve the consequential transitions by which encounters become records, records become data, data and other evidence enter representations, models and interpretations are revised, and provisional claims reach closure. Its objective is to make the project's reasoning, transformations, assumptions, revisions, failures, and unresolved problems traceable without converting research into exhaustive recording of every action. The discussion proceeds through the research log, decision log, assumption log, data provenance, model provenance, interpretation history, revision history, negative results, and unresolved questions. The method is selective and lineage-oriented: documentation is strongest when it preserves the relations required to explain how a consequential research state emerged from earlier states.

Research documentation serves several functions simultaneously. It supports internal memory in long projects, enables collaborators to coordinate across differentiated roles, supplies evidence for governance and correction, preserves the conditions for historical re-epistemization developed in Section 9.15, and prepares the reproducibility and reusability architectures developed in the following sections. These functions overlap, yet they should not be collapsed. Documentation can be adequate for accountability while insufficient for computational reproduction. A reproducible script can rerun successfully while leaving the reasons for its category choices undocumented. A rich interpretive memo can preserve conceptual history without supplying the data transformations required to reconstruct an estimate. The documentary architecture should therefore reflect the plurality of research objects and epistemic operations within the project.

Exhaustiveness is neither feasible nor desirable as a general principle. Continuous recording can produce large archives in which consequential events become difficult to find, can create privacy or security risks, and can shift effort from inquiry toward administration. Selectivity is therefore part of documentation design. The relevant question is whether omission of a record would materially weaken later reconstruction of evidence, inference, authority, interpretation, scope, revision, or uncertainty. Temporary notes, debugging traces, redundant files, and exploratory operations can often be summarized or discarded when their disappearance does not alter such reconstruction. Consequential transformations and decisions require stronger retention.

Definition 9.277 (Research documentation architecture). A *research documentation architecture* is the coordinated set of logs, provenance records, version histories, interpretive records, and open-problem registers through which materially consequential research operations, decisions, assumptions, transformations, revisions, failures, and unresolved questions remain attributable and reconstructible across the life of a project.

Definition 9.277 makes documentation relational. The objective is not merely to

Table 9.9: Documentation objects within an integrated research project

Record type	Lineage to preserve	Principal project function	Characteristic loss when absent
Research log	Temporally ordered material events, encounters, operations, anomalies, and outputs	Reconstruction of project trajectory and event context	Later states survive while the path through which they emerged becomes opaque
Decision log	Decision, alternatives, evidence, rationale, actor, scope, and review condition	Reconstruction of consequential judgment	Choices appear inevitable or arbitrary after their original decision context disappears
Assumption log	Assumption, role, scope, source, dependency, status, and revision trigger	Visibility of premises carried across methods and models	Hidden assumptions migrate into downstream claims as if they were findings
Data provenance	Source, custody, selection, transformation, versioning, and analytical use	Reconstruction of evidential transformation chains	Properties introduced by research processing become difficult to distinguish from source properties
Model provenance	Model family, version, categories, data, code, parameters, assumptions, and revision path	Reconstruction of formal and computational lineage	Outputs survive while the model state that generated them becomes indeterminate
Interpretation history	Competing readings, evidential bases, adjudication, residual scope, and change	Preservation of interpretive plurality and judgment	Final narratives erase serious alternatives and the reasons they changed
Revision history	Prior state, revised state, trigger, reason, affected objects, and consequences	Reconstruction of epistemic change	A project records that something changed while losing why and with what downstream effect
Negative results	Tested expectation, conditions, procedure, result, diagnostic status, and implication	Preservation of informative constraint and failed pathways	Unsupported repetition and retrospective selection of only successful paths
Unresolved questions	Open problem, present evidence, blockage, consequence, dependencies, and reopening conditions	Continuity of inquiry across provisional closure	Remaining uncertainty disappears from the record and later closure appears stronger than warranted

preserve isolated files. A data version gains documentary value when it remains linked to its source and transformations; a decision becomes intelligible when linked to the alternatives considered and the evidence available; a revision becomes reconstructible when linked to the earlier state and the reason for change. The documentary unit is therefore often a relation among states, objects, actors, and reasons.

Table 9.9 summarizes the principal documentation objects developed below. The table distinguishes the documentary object, the lineage that should remain visible, the project function supported by that lineage, and a characteristic loss produced when documentation is absent or too weak.

The objects in Table 9.9 interact. A decision can change a dataset, a dataset change can trigger a model revision, a model revision can alter interpretation, and an unresolved question can explain why a negative result remains ambiguous. A strong architecture therefore links records across these domains where the relation is consequential. This linkage is especially important in AI-assisted and highly computational workflows, where many transformations can occur between source material and final claim within a short period of time.

9.18.1 Research Log

The research log provides the temporal backbone of project documentation. Its role is to preserve a sufficiently ordered record of consequential events so that later investigators can reconstruct when important evidence, anomalies, decisions, revisions, and

outputs entered the project. Its objective is to prevent the final project state from erasing the sequence through which inquiry developed. The log can contain field encounters, archival visits, data acquisitions, analysis runs, meetings, model changes, unexpected observations, review events, release decisions, ethical incidents, and other milestones appropriate to the research design.

A research log differs from a complete activity diary. The distinction follows the principle of selective traceability. An entry warrants preservation when its timing, context, content, or consequences could matter to later reconstruction. A failed data import resolved without analytical consequence can remain a technical trace. Discovery that a source file used in several analyses contained a coding error is a research event because it changes the evidential state of the project. Similarly, an informal conversation may become documentarily relevant if it substantially changes a category, case-selection rule, or interpretation.

Definition 9.278 (Research log). *A research log is a temporally ordered record of materially relevant project events, encounters, operations, anomalies, decisions, outputs, and changes, together with identifiers or links sufficient to connect those events to the research objects and actors they affected.*

Temporal ordering can matter independently of content. The same model revision has a different epistemic meaning if it occurred before a discrepant result was observed than if it occurred after that result. A coding category developed before fieldwork differs from one introduced after researchers encountered a recurrent pattern. A robustness specification fixed before seeing an estimate has a different relation to selection than one added after observing instability. Documentation need not infer motive from sequence, yet preserving sequence allows later evaluation of possible dependence.

Logs can also preserve the relation between project time and historical time. In a fast-changing field, data collected in January and interpreted in June can belong to different institutional or technological contexts. When the external environment is itself evolving, the log should connect relevant project events to contextual changes that affect their interpretation. This is particularly important for longitudinal research and for studies of institutions, platforms, policies, conflicts, markets, or technical systems whose conditions can change during inquiry.

Proposition 9.279 (Temporal traceability). *When the epistemic meaning of a research state can depend materially on the sequence or timing of preceding events, the documentation architecture should preserve enough temporal ordering to reconstruct the relation among those events, the objects they affected, and the project state that followed.*

The proposition does not require timestamping every thought or keystroke. Temporal resolution should be proportionate to the processes being studied and the decisions being made. A daily or event-based log may be sufficient for one project, while a real-time experimental or computational workflow can require automated records with finer granularity.

9.18.2 Decision Log

Research projects repeatedly make decisions that are underdetermined by formal rules. Investigators choose fields, cases, stopping points, variables, archives, transformations, representations, models, thresholds, exclusions, interpretations, disclosure practices, and closure conditions. Section 9.17 allocated authority and responsibility for such decisions. The decision log records how consequential choices were actually made.

A useful decision record goes beyond the selected option. It preserves the decision object, the alternatives that were seriously considered, the evidence and constraints available at the time, the rationale for selection, the actor or body exercising authority, the scope of the decision, and the conditions under which it should be reviewed. This structure reduces retrospective rationalization. Once a project succeeds, earlier choices can appear obviously correct; once it fails, they can appear obviously mistaken. Reconstructing the contemporaneous decision state allows later evaluation to distinguish poor judgment from reasonable judgment under incomplete knowledge.

Definition 9.280 (Research decision record). *A research decision record documents a materially consequential project choice together with the alternatives considered, the evidence and constraints available, the rationale used, the responsible decision authority, the intended scope, and any specified conditions for later review or reversal.*

Decision logs are especially valuable where methodological discretion can affect inference. Exclusion rules, missing-data treatments, coding schemes, model-selection criteria, historical cutoffs, and interpretation thresholds can each alter a result. Recording the rationale does not convert discretion into objectivity. It makes the exercise of discretion inspectable and therefore more contestable.

The log should also preserve decision dependencies. A later choice can be constrained by an earlier one: a field selection can determine which data exist; a category choice can determine which measurements are possible; an ethical restriction can eliminate a method; a software dependency can narrow a model family. If later records show only the final decision, those upstream constraints can disappear from view. Linking decisions makes path dependence in the research design visible.

Proposition 9.281 (Decision–rationale coupling). *Consequential research decisions become more reconstructible when the selected action remains linked to the alternatives, evidence, constraints, authority, and rationale present at the time of choice, together with the conditions under which the decision may be reopened.*

A decision log can remain concise. High-frequency routine choices can be governed by predefined procedures and recorded through configuration files or automated metadata. Stronger narrative documentation is warranted where the choice is unusually consequential, discretionary, irreversible, contested, or capable of changing the interpretation of later results.

9.18.3 Assumption Log

Assumptions enter research at several levels. Some concern the studied world: stationarity, continuity, independence, strategic behavior, institutional stability, cate-

gory persistence, or the existence of a proposed mechanism. Others concern research operations: sampling adequacy, measurement correspondence, missingness, source reliability, model form, parameter range, translation, coding, or computational approximation. Still others concern practical constraints, such as what can be observed, preserved, disclosed, or intervened upon. The assumption log makes these premises visible as premises.

Assumption visibility is especially important in integrated projects because assumptions can migrate across methods. A category initially introduced for data collection can later become embedded in a statistical variable, a graph node type, a simulation state, and a substantive interpretation. Repetition across representations can then create an appearance of independent confirmation even though the outputs inherit the same upstream premise. Documentation should therefore record assumption dependencies as well as assumption content.

Definition 9.282 (Research assumption register). *A research assumption register identifies materially consequential assumptions used by a project, their analytical or operational role, scope, source or justification, dependent methods and claims, current epistemic status, and conditions that would trigger review, relaxation, or replacement.*

The register should distinguish assumptions from findings. A model can examine what follows if a network is approximately stable over a given interval without establishing that such stability obtains. A historical reconstruction can provisionally treat two archival classifications as comparable while preserving uncertainty about that equivalence. A qualitative coding procedure can use a working distinction to organize inquiry before the distinction is theoretically defended. These assumptions can be legitimate research devices when their status remains visible.

Assumptions also vary in depth. Some are local and technical, such as a numerical tolerance. Others organize the research object itself, such as the boundaries of a field or the categories through which actors are represented. Sensitivity analysis in Section 9.12 can reveal which assumptions materially affect a claim. The assumption log should then reflect that consequence: assumptions to which key conclusions are highly sensitive warrant stronger justification and clearer monitoring.

Proposition 9.283 (Assumption visibility). *When a premise materially conditions the production, interpretation, or scope of a consequential research claim, the documentation architecture should preserve that premise as an identifiable assumption and link it to the methods, representations, models, or decisions that depend upon it.*

The assumption log should remain revisable. An assumption can become a supported finding, a rejected premise, a narrower boundary condition, or an unresolved uncertainty. Preserving these status changes prevents the project from retrospectively presenting an exploratory premise as if it had always been established.

9.18.4 Data Provenance

Data provenance records how evidential materials acquire the form in which they are analyzed. Its role in this section is documentary rather than custodial. Section 9.17 addressed authority over collection, access, transformation, retention, and reuse. Prove-

nance records the lineage of the data object across those operations so that later users can determine what was collected or obtained, from where, under which selection rules, by whom or through which system, and how the material changed before it entered analysis.

The term *data* is used broadly here. It can include measurements, survey responses, interview materials, fieldnotes, archival records, administrative extracts, images, documents, relational data, computational traces, derived variables, coded qualitative materials, and other structured or unstructured evidential objects. The appropriate provenance fields differ across these forms. A transcript requires information different from a sensor stream, and an archival corpus requires documentation different from a merged administrative dataset. The common requirement is lineage sufficient to interpret consequential transformations.

Definition 9.284 (Data provenance chain). A *data provenance chain* is a linked record of the origin, acquisition or generation, custody, selection, exclusion, transformation, merging, coding, aggregation, versioning, and analytical use of a data object insofar as those operations can materially affect its evidential meaning or the claims derived from it.

Provenance should preserve both transformation and loss. Cleaning can remove observations; aggregation can erase heterogeneity; anonymization can suppress relational information; translation can alter semantic distinctions; record linkage can introduce false matches and exclusions; coding can convert open-ended materials into categories; normalization can change scale; imputation can insert model-based values. These operations may be entirely warranted, yet their evidential consequences should remain reconstructible.

Derived datasets require explicit ancestry. A final table used for estimation can depend on multiple source files, extraction dates, joins, exclusions, recodings, and manually resolved conflicts. Version identifiers alone are insufficient when they do not reveal the transformation path. Where feasible, executable pipelines can preserve part of this lineage; where execution is impossible or inappropriate, a structured transformation record can serve the same documentary function.

Data provenance also interacts with uncertainty. Section 9.14 distinguished measurement, historical, relational, and other forms of uncertainty. Provenance records should preserve uncertainty introduced or discovered during data production rather than allowing it to disappear after transformation. A variable derived from uncertain source categories should not acquire artificial certainty merely because it appears in a clean analytical table.

Proposition 9.285 (Transformation-lineage preservation). *Where a data transformation can materially alter inclusion, meaning, scale, uncertainty, relational structure, or comparability, the resulting data object should remain linked to the source state, transformation rule or rationale, responsible operation, and version through which that alteration occurred.*

The proposition is compatible with legitimate restrictions. Sensitive source data can remain inaccessible while provenance metadata document that restricted transformations occurred. Reconstructibility can therefore be separated from unrestricted disclosure, although severe access constraints may limit the depth of later

verification.

9.18.5 Model Provenance

Model provenance extends documentary lineage from data into formal, statistical, computational, geometric, network, dynamical, and other analytical representations. Section 9.11 treated models as revisable objects in dialogue with evidence, while Section 9.15 required preservation of consequential model versions for future re-epistemization. The present subsection specifies the documentation needed to reconstruct which model state produced a particular output or claim.

A model state can depend on more than code. It can include category definitions, structural assumptions, equation forms, objective functions, priors, parameter values, calibration procedures, software and library versions, random seeds, numerical tolerances, initialization rules, training data, prompts or model-provider versions in AI-assisted components, and post-processing procedures. A computational artifact is therefore only one layer of model provenance.

Definition 9.286 (Model provenance chain). *A model provenance chain is the documented lineage connecting a model output or model-dependent claim to the relevant model family and version, category system, assumptions, data inputs, code or formal specification, parameterization, computational environment, calibration or estimation procedure, and consequential revisions that generated it.*

This chain supports several forms of diagnosis. When an output changes, researchers can ask whether the change came from data, code, parameter values, category definitions, software versions, model structure, or random initialization. When two collaborators obtain different results, provenance can localize the divergence. When a later reanalysis revises a model, the earlier output remains interpretable within its original configuration.

Model provenance should also retain non-executable conceptual changes. A model may preserve identical equations while the interpretation of a state variable changes; a network may use the same adjacency matrix while the meaning of an edge is revised; a simulation may retain its code while a parameter previously treated as behavioral becomes institutionally interpreted. Such semantic changes can affect inference even if no computational diff captures them. Versioning should therefore include model meaning as well as implementation.

AI-assisted modelling increases the importance of this distinction. Section 9.16 required operation records and dependency profiles for machine-assisted formalization, simulation, and theory revision. Model provenance should link those records when an AI-generated specification, code segment, parameter proposal, or interpretation becomes part of a consequential model state. Generated code that later behaves correctly can still have an important provenance relation to the system and prompt through which it was produced.

Proposition 9.287 (Model-lineage traceability). *A model-dependent result becomes documentarily reconstructible when the project can identify the model state that generated it and trace that state through the consequential data, category, assumption, formal, computational, parameter, and revision dependencies on which the result rests.*

Granularity should again follow consequence. A project need not preserve every intermediate optimization checkpoint or debugging state. It should preserve model states whose differences can alter interpretation, inference, reproducibility, uncertainty, or downstream reuse.

9.18.6 Interpretation History

Interpretation history documents how the project understood its evidence and why that understanding changed. This component is necessary because evidential and model provenance alone cannot reconstruct meaning. Two researchers can inspect the same materials and formal results yet organize them through different causal, historical, relational, or normative readings. Section 9.10 treated such plurality as a possible outcome of cross-method adjudication, while Section 9.15 required serious superseded interpretations to remain available for future reinterpretation. The present subsection integrates those insights into ordinary documentation practice.

Interpretation history can include analytic memos, competing mechanism accounts, rival historical narratives, category debates, field-based reflections, participant interpretations, explanations of anomalous cases, and records of cross-method disagreement. The objective is not to preserve every speculative thought. It is to retain interpretations that materially shaped what evidence was sought, how findings were connected, which claims were advanced, or why the project changed direction.

Definition 9.288 (Interpretation history). An *interpretation history* is a versioned record of materially consequential readings of evidence or research objects, the premises and evidence supporting those readings, their relations of compatibility or conflict, the reasons for their revision or non-selection, and any residual domain in which a superseded interpretation remains viable.

Interpretation histories are especially important where evidential support is asymmetric. One reading may explain quantitative regularities while another better fits historical sequence; one may accord with institutional documents while another fits participant accounts; one may be strongly supported within one field site and weakly supported elsewhere. The final narrative may legitimately privilege one interpretation, but documentation should preserve the structure of the adjudication when that structure materially affects scope.

Interpretive changes should be linked to triggers. A new source can overturn an earlier reading. A category revision can reveal that two previously combined processes should be separated. A model can expose a hidden incompatibility. A participant challenge can identify a standpoint omitted from the initial account. A later historical event can alter the salience of an earlier mechanism without making that mechanism retrospectively inevitable. Linking changes to triggers prevents interpretation history from becoming a sequence of unexplained opinions.

Proposition 9.289 (Interpretive non-erasure). *When a materially consequential interpretation is revised, narrowed, or displaced, the documentation architecture should preserve enough of its evidential basis, premises, earlier scope, and revision trigger to explain both why it was once plausible and why the project later changed its interpretive position.*

This proposition supports epistemic humility. A project can state a preferred interpretation clearly while preserving the conditions under which alternative readings remain possible. Documentation thereby distinguishes reasoned closure from erasure of prior disagreement.

9.18.7 Revision History

Revision is a pervasive operation across an integrated research project. Questions change, boundaries move, categories are refined, datasets are corrected, models are replaced, interpretations narrow, governance arrangements change, and uncertainty statements are updated. A revision history records these changes at the level required to reconstruct their causes and consequences. Its role is to make the evolution of the project itself an inspectable object.

Version control can preserve differences between files, yet revision history requires more than a technical diff. A line changed in code can correct a bug, alter an estimator, implement a new theoretical assumption, or merely improve formatting. A category renamed in a document can reflect editorial cleanup or a substantive reconceptualization. Documentation should therefore distinguish the existence of a change from its epistemic meaning.

Definition 9.290 (Research revision history). *A research revision history links a materially consequential change to the prior project state, the revised state, the trigger and rationale for revision, the research objects and claims affected, the responsible decision process, and any downstream analyses or interpretations that require reconsideration.*

Revision history should support propagation. If a data-coding correction changes several derived variables, the project should be able to identify which models and claims depend on the affected version. If a category is redefined, the history should identify whether earlier fieldnotes, coded materials, statistical variables, and model states need reinterpretation. If an ethical review narrows permissible data use, the revision should propagate into access, analysis, release, and preservation decisions.

This dependency-aware perspective prevents local correction from being mistaken for complete correction. A project can fix the immediate source of an error while leaving downstream figures, interpretations, or published artifacts unchanged. Revision documentation therefore supports both epistemic and governance duties by identifying the radius of consequence.

Revision history also preserves legitimate reversibility. A change can later be reconsidered if its predecessor and rationale remain available. Reversibility does not imply that projects should continually oscillate among versions. It means that closure is less brittle when earlier states can be reconstructed and compared under changed evidence.

Proposition 9.291 (Revision-causality traceability). *A consequential project revision should remain linked to the condition that triggered it, the reason for change, the prior and revised states, and the dependent objects or claims whose epistemic status may have changed as a result.*

This principle complements historical re-epistemization. Section 9.15 preserves

consequential versions for future inquiry; revision history explains the pathways through which one version became another.

9.18.8 Negative Results

Negative results are a distinctive documentation object because they can constrain future inquiry even when they do not support the expected claim. Chapter 6 distinguished a negative research result from research failure: an adequately designed inquiry can produce evidence inconsistent with an expected effect, while a poorly identified or weakly implemented study can yield an uninformative absence. Documentation should preserve that distinction.

Negative results take heterogeneous forms: an absent association, a failed mechanism prediction, poor model performance outside calibration, an unchanged intervention target, missing historical evidence expected under a proposed account, or a simulation showing that a mechanism is insufficient under plausible conditions. These outcomes constrain different claims and therefore require different contextual records.

Definition 9.292 (Negative-result record). A *negative-result record* documents a materially informative absence, failed prediction, null or contrary finding, unsuccessful analytical pathway, or bounded failure of a proposed mechanism together with the tested expectation, research conditions, procedure, relevant uncertainty, diagnostic interpretation, and the claims or future pathways the result constrains.

The record should preserve diagnostic status. A negative finding can strongly challenge a hypothesis when measurement, design, implementation, and inferential resolution are adequate, while the same observed absence can be weakly informative under poor measurement, case selection, implementation, or historical coverage. Recording only “no effect” or “failed” compresses these distinctions.

Negative results can also reveal boundary conditions across institutions, scales, and historical periods. Documentation should therefore connect them to the boundary, scale, historical window, method, and representation under which they occurred.

Preservation can reduce inefficient repetition while leaving room for justified re-examination when data, measurement, categories, identification, or theoretical questions change.

Proposition 9.293 (Negative-result legibility). A *negative result contributes to cumulative inquiry when the project preserves enough information to determine what expectation was tested, under which conditions, with what inferential resolution, why the result was judged informative or inconclusive, and which claims or future research paths it constrains.*

This proposition also resists publication-shaped memory. If only successful pathways are documented, later readers can infer an unrealistically linear research process and underestimate the space of alternatives that evidence has already constrained.

9.18.9 Unresolved Questions

Research projects often close while consequential questions remain open because evidence is unavailable, methods disagree, categories remain unstable, access is constrained, models remain observationally equivalent, ethical conditions limit inquiry, or the issue lies beyond project scope. Documentation should preserve these questions as structured objects alongside stabilized claims.

An unresolved question should identify what remains unknown or disputed, why the project cannot resolve it, which evidence or assumptions it depends upon, how it affects current claims, and what could make it tractable later. A future investigator can then inherit a defined problem rather than reconstructing uncertainty from scattered caveats.

Definition 9.294 (Open-question register). *An open-question register records materially unresolved research questions together with their present evidential and conceptual state, the source of blockage or underdetermination, their consequences for current claims, relevant dependencies, and the evidence, methodological development, contextual change, or theoretical revision that could justify reopening them.*

Open questions should retain differentiated status. They can concern central theoretical issues, narrow technical uncertainty, irreducible cross-method disagreement, or problems newly exposed by a negative result or category revision. Materiality, tractability, and consequence can guide future planning without reducing these questions to a single scale.

The register can also preserve questions deliberately left unresolved because of ethical limits, participant interests, privacy, security, legal restrictions, or disproportionate research cost. Recording that reason distinguishes principled non-pursuit from accidental omission.

Unresolved questions connect directly to uncertainty architecture. Section 9.14 records what is uncertain and how that uncertainty affects claims. The open-question register identifies where a future research operation might reduce, reinterpret, or better characterize that uncertainty. The two records should therefore remain linked where appropriate.

Proposition 9.295 (Open-question continuity). *When an unresolved issue materially limits the scope, interpretation, robustness, or practical use of a project claim, the documentary architecture should preserve the issue as an identifiable open question together with its present blockage, consequence, and plausible conditions for future reopening.*

Together, these records form a linked documentary architecture proportionate to the project's scale and consequence while preserving the pathways by which consequential claims become possible. Section 257 develops reproducibility as the next design problem: the conditions under which research operations, documentary pathways, analyses, and interpretations can be reconstructed or repeated from the preserved record.

9.19 Reproducibility

Section 9.18 developed the documentation architecture through which consequential research events, decisions, assumptions, data transformations, model states, interpretations, revisions, negative results, and unresolved questions remain traceable. The present section develops the reproducibility architecture that such documentation can support. Its role is to specify the different senses in which a later investigator may reconstruct, rerun, re-execute, or critically retrace an earlier research pathway. Its objective is to prevent the term *reproducibility* from collapsing distinct epistemic tasks into a single binary judgment. The discussion proceeds through computational reproducibility, documentary reproducibility, analytical reproducibility, interpretive transparency, historical reconstructability, reproducibility under changing data, reproducibility under changing categories, and the scope conditions of reproduction. The method is profile-based: each reproduction claim is evaluated relative to a specified research object, preserved conditions, permitted changes, expected correspondence, and diagnostic purpose.

Reproducibility is especially important in an integrated GR research design because the research object rarely coincides with a single numerical output. A project can include archival records, field materials, coded corpora, transformed datasets, relational maps, model families, simulations, interpretive judgments, category revisions, uncertainty records, and governance decisions. Different components admit different forms of reproduction. A deterministic program can sometimes be rerun bit for bit. A historical interpretation cannot be reproduced in that computational sense, yet its evidential and inferential pathway can remain inspectable. A longitudinal dataset can change after the original analysis, requiring distinction between reproduction from the earlier data vintage and reanalysis of the updated record. A category can change meaning across time, making literal reuse less informative than a documented semantic bridge.

Within this book, *reproducibility* refers primarily to reconstruction or rerunning of an earlier research pathway from preserved materials and specifications. *Replication*, developed later in the chapter's treatment of cumulative research, concerns a new inquiry that tests a claim under deliberately preserved or varied research conditions. The distinction is analytical rather than jurisdictional: disciplinary vocabularies vary, and some traditions use the terms differently. What matters for project design is that the intended operation be stated explicitly rather than inferred from terminology alone.

Definition 9.296 (Reproducibility architecture). A *reproducibility architecture* is the coordinated set of preserved materials, executable specifications, provenance relations, interpretive records, version states, and comparison criteria through which a materially consequential research pathway can be reconstructed or rerun at a stated level of correspondence under stated conditions.

Definition 9.296 makes reproducibility relational. The target is not simply an output. It is a relation among a source state, a sequence of transformations, a research environment, a set of assumptions, and a comparison rule. Two analysts can obtain numerically identical outputs while reproducing different conceptual objects if they assign different meanings to the underlying categories. Conversely, two reruns can

Table 9.10: Reproducibility modes within an integrated research project

Reproduction mode	Primary target	Correspondence to preserve	Characteristic diagnostic value
Computational	Executable transformation from specified inputs to outputs	Environment, code, dependencies, data state, parameters, randomness controls, and output relation	Distinguishes executable instability from substantive analytical disagreement
Documentary	Traceable pathway from source material to consequential research state	Provenance, decisions, assumptions, versions, and links among records	Tests whether the published or preserved account can be reconstructed from the documentary record
Analytical	Derivation of a result or claim through specified analytical operations	Analytical object, procedure, assumptions, comparison rule, and inferential target	Distinguishes result dependence on hidden discretion from dependence on declared analysis choices
Interpretive	Reconstruction of how evidence supported an interpretation	Evidential basis, category use, interpretive premises, alternatives, and adjudication	Makes interpretive judgment inspectable without requiring a unique reading
Historical	Reconstruction of an earlier as-of epistemic state	Contemporaneous evidence, context, categories, models, and recorded uncertainty	Protects against hindsight substitution and present-category projection
Changing data	Reproduction across data vintages or evolving records	Version identity, update relation, transformation continuity, and claim comparison	Separates data evolution from code, model, or inferential instability
Changing categories	Reproduction across semantic or classificatory change	Category version, bridge relation, retained distinctions, and translated claim scope	Distinguishes semantic change from empirical change and reveals losses introduced by recoding
Scope-bounded	Reproduction where some conditions cannot or should not be preserved	Explicit target, unavailable conditions, permissible substitutions, and residual limitation	Prevents partial reconstruction from being reported as stronger reproducibility than the design supports

differ numerically while reproducing the same substantive analytical relation within a stated tolerance when stochastic procedures, numerical solvers, updated software, or non-identical hardware are involved.

A useful reproduction claim therefore requires a profile. The profile identifies what is being reproduced, what should remain invariant, what may legitimately change, and how correspondence will be judged. Table 9.10 summarizes the principal modes developed below.

Definition 9.297 (Reproduction profile). *A reproduction profile specifies the research object or pathway targeted for reproduction, the source state from which reproduction begins, the conditions intended to remain stable, the changes permitted by the design, the expected form and tolerance of correspondence, and the discrepancies that would trigger diagnostic review.*

The profile prevents a common ambiguity. A project can be computationally reproducible while analytically underdocumented, documentarily reconstructible while dependent on unavailable proprietary software, or interpretively transparent while its source materials cannot be publicly redistributed. Reproducibility should therefore be represented as a differentiated profile rather than assigned as a single global property of the project.

9.19.1 Computational Reproducibility

Computational reproducibility concerns executable research transformations. Its local object can be a data-cleaning pipeline, statistical analysis, network construction, optimization procedure, simulation, numerical solver, machine-learning workflow, figure-generation script, or any other procedure in which a specified computational state is expected to produce a specified class of outputs. Its role is to make the relation between computational inputs and outputs inspectable and rerunnable.

A minimal computational record normally includes source data identifiers or hashes where appropriate, transformation code, model code, parameter settings, dependency versions, execution environment, random seeds or randomness policy, solver settings, and the expected output or diagnostic summary. In some workflows, hardware characteristics, accelerator libraries, parallelization strategy, locale, operating system, or external service version can also influence results. The required granularity depends on the consequence of those dependencies for the claim being supported.

Definition 9.298 (Computational reproduction envelope). *A computational reproduction envelope is the set of input, software, parameter, environment, randomness, and execution conditions within which a computational research operation is expected to yield outputs corresponding to an earlier result under a stated comparison rule.*

Correspondence need not always mean bitwise identity. Exact identity is appropriate for some deterministic transformations. Stochastic models can instead require agreement in seeded output, distributional properties, parameter estimates within tolerance, qualitative regime, or inferential conclusion. Iterative solvers can produce small numerical differences across libraries or hardware while preserving the same solution class. A reproduction profile should therefore specify the expected level of invariance before a discrepancy is observed.

This specification matters because post hoc tolerance can convert failed reproduction into an apparently successful one. If a project decides only after seeing a discrepancy that “approximately similar” outputs are sufficient, the acceptance rule becomes entangled with the result. Pre-specified or at least contemporaneously documented comparison rules strengthen diagnostic interpretation.

The computational envelope should also identify external dependencies. An API result can change because the external system changed. A hosted language model can produce different outputs because the provider updated the model. A database query can return a changed corpus because the underlying archive is live. A package can modify a default algorithm between versions. When external state is material, computational reproducibility requires either preserving a fixed snapshot, recording the exact external version, or explicitly classifying the operation as dependent on a changing service.

Proposition 9.299 (Execution-state traceability). *A computational result becomes meaningfully reproducible when the project preserves enough of the executable state and its dependencies to distinguish discrepancies caused by execution conditions from discrepancies caused by data, model, analytical, or substantive change.*

The proposition makes reproducibility diagnostic rather than ceremonial. A successful rerun establishes that an earlier computational pathway can be reconstructed

under the tested conditions; it does not establish that the model is correct, the categories are adequate, or the inference is warranted. A failed rerun likewise requires localization. The failure can arise from missing data, code defects, version drift, nondeterminism, undocumented preprocessing, unavailable dependencies, or a mistaken assumption about what the earlier output represented.

Computational reproducibility therefore feeds back into the model–evidence dialogue developed in Section 9.11. When a claimed empirical discrepancy disappears after an environment error is corrected, the revision belongs to the execution layer. When the discrepancy persists under a successfully reproduced pipeline, deeper analytical or substantive revision becomes more plausible.

9.19.2 Documentary Reproducibility

Documentary reproducibility concerns whether the project record is sufficient to reconstruct how a consequential research state came into being. It draws directly on the architecture developed in Section 9.18, yet its criterion is stronger than mere record existence. A collection of logs, files, and versions supports documentary reproducibility only when a later investigator can use them to recover the relevant lineage with reasonable fidelity.

A documentary reproduction can begin from a claim, table, figure, model state, coding decision, or interpretation and work backward toward the sources and decisions that support it. It can also proceed forward from a source object to identify how that object was selected, transformed, represented, modeled, and incorporated into later claims. These two directions reveal different failures. Backward reconstruction can expose unsupported final outputs. Forward reconstruction can reveal evidence that entered the project but disappeared from the final narrative.

Definition 9.300 (Documentary reproduction path). A *documentary reproduction path* is a traversable sequence of provenance, decision, assumption, version, and revision relations through which a later investigator can reconstruct the documented lineage connecting a consequential project state to the materials and judgments from which it emerged.

Traversability matters more than volume. A repository can contain every intermediate file while lacking stable identifiers or relations among them. In that case, the record is extensive yet weakly reproducible. Conversely, a selective architecture can support strong reconstruction when consequential objects have stable identifiers, transformations are linked, decisions preserve rationale, and version changes remain attributable.

Documentary reproduction should preserve contemporaneous status. A later note explaining an earlier decision is useful, yet it should be distinguished from a record created when the decision was made. The distinction protects against retrospective rationalization and allows later readers to see which evidence and assumptions were actually available at the time.

The architecture can also support audit samples. A large project may be too extensive for complete end-to-end reconstruction of every minor output. It can define high-consequence claims, high-risk transformations, or representative pathways for

periodic documentary reproduction. If such samples repeatedly fail because lineage is broken, the result becomes evidence that the documentation architecture requires revision.

Proposition 9.301 (Lineage reconstruction criterion). *Documentary reproducibility is supported when a consequential claim or project state can be traced through the documented sequence of source materials, transformations, assumptions, decisions, versions, and revisions that materially contributed to its formation.*

This form of reproducibility is particularly important for mixed and AI-assisted workflows. A final paragraph, code file, category scheme, or model specification can appear coherent even when its development passed through many temporary machine-generated or collaborator-generated objects. Documentary reproduction allows the project to identify which of those objects were consequential and which were exploratory, preventing output polish from erasing production history.

9.19.3 Analytical Reproducibility

Analytical reproducibility concerns whether the inferential operation connecting evidence to a stated analytical result can be reconstructed and re-executed. It occupies a level between computational rerunning and substantive replication. A statistical estimate, qualitative coding result, relational map, historical comparison, formal derivation, or model-based classification can all have analytical procedures that deserve independent reconstruction even when their computational implementation differs.

The relevant object is an analytical contract: the research object, data or evidence state, inclusion and exclusion rules, transformations, category definitions, model or reasoning procedure, comparison rule, and inferential target. Reproduction asks whether another competent investigator, using that contract and the preserved materials, can derive a result that corresponds to the earlier analytical output under the specified criterion.

Definition 9.302 (Analytical reproduction contract). *An analytical reproduction contract specifies the research object, evidential state, analytical operations, category and boundary choices, assumptions, comparison rule, and inferential target that must be preserved or explicitly varied when reconstructing an earlier analysis.*

The contract does not eliminate judgment. Interpretive coding can require context-sensitive decisions; archival comparison can depend on source criticism; network construction can require boundary choices; statistical analysis can include defensible alternatives for missing data or functional form. Analytical reproducibility is strengthened when such discretion is exposed rather than hidden behind software output or procedural labels.

A useful design distinguishes fixed operations from judgment-bearing operations. Fixed operations can often be implemented exactly. Judgment-bearing operations should preserve criteria, exemplars, disagreement procedures, uncertainty, and recorded decisions. When a second analyst reaches a different result, the project can then ask whether the difference comes from execution error, a legitimate discretionary choice, category ambiguity, evidence insufficiency, or a deeper interpretive disagreement.

Analytical reproduction can therefore generate new information even when it does not reproduce the original result exactly. A discrepancy localized to one classification rule may reveal that the claim is highly sensitive to that rule. A discrepancy distributed across many small decisions may indicate that the apparent precision of the original output depended on a larger discretionary field. Such findings connect directly to the sensitivity architecture developed in Section 9.12.

Proposition 9.303 (Analytical correspondence). *An analytical result is reproducible at a stated level when a competent reconstruction from the specified evidence and analytical contract yields an output corresponding to the earlier result under the declared comparison rule, with consequential discrepancies attributable to identifiable analytical choices or unresolved uncertainty.*

This proposition avoids equating reproducibility with identical syntax. An independent implementation can be stronger evidence of analytical reproducibility than rerunning the original code when the two implementations instantiate the same analytical contract through different technical pathways. Conversely, identical code can reproduce an output without independently testing whether the analytical specification was sufficiently explicit.

9.19.4 Interpretive Transparency

Some research outputs depend on interpretation in ways that cannot be reduced to a deterministic sequence of operations. Historical explanation, interview analysis, ethnographic reconstruction, conceptual analysis, case interpretation, institutional reading, and cross-method adjudication can require situated judgment. For such work, demanding a unique reproduced interpretation would confuse transparency with interpretive identity.

Interpretive transparency concerns reconstructibility of the path by which an interpretation became warranted. The evidential basis should be identifiable; category use should be explicit enough to inspect; relevant alternatives should be preserved where materially serious; inferential steps should be stated; and the reasons for preferring, narrowing, combining, or suspending interpretations should remain available.

Definition 9.304 (Interpretive reconstruction record). *An interpretive reconstruction record preserves the evidential materials, category definitions, contextual assumptions, inferential moves, competing readings, adjudicative reasons, residual uncertainty, and scope conditions required to reconstruct how a project arrived at a materially consequential interpretation.*

The record supports critical disagreement. A later reader can accept the evidence while rejecting the interpretation, challenge a category while preserving the historical record, or propose a new reading using evidence the original project already preserved. This possibility is a strength rather than a failure of interpretive research. Reproducibility at the interpretive level concerns the transparency of the reasoning relation, not forced convergence of competent readers.

Interpretive transparency also constrains quotation and excerpt selection. When conclusions depend heavily on selected passages, examples, cases, or archival frag-

ments, the selection basis should be sufficiently visible to evaluate whether the interpretation depends on atypical or strategically chosen material. Full disclosure can be limited by privacy, consent, legal restrictions, community stewardship, or source availability. In such cases, the project can preserve controlled-access records, structured summaries, audit procedures, or other legitimate substitutes while documenting the resulting limitation.

Proposition 9.305 (Interpretive reconstructibility). *A consequential interpretation is reproducibly transparent when a later competent reader can reconstruct the evidential and inferential pathway that made the interpretation plausible, identify the principal judgment points and alternatives, and locate the residual uncertainty without being required to adopt the same interpretation.*

This proposition aligns reproducibility with methodological pluralism. The project can preserve serious disagreement while still demanding rigorous traceability. It also prepares the transition to reusability in Section 258, because reusable interpretive materials require enough context to support new readings without pretending that the original reading was mechanically generated.

9.19.5 Historical Reconstructability

Historical reconstructability addresses reproduction across epistemic time. Section 9.15 developed historical re-epistemization as the preservation of records, alternative models, superseded interpretations, context, versioned categories, and versioned models for future inquiry. Reproducibility adds a more specific question: can a later investigator reconstruct the earlier project's as-of epistemic state closely enough to understand what could reasonably have been known, modeled, categorized, and inferred at that time?

A historical reconstruction should distinguish at least three temporal layers: the state of the world or field being studied, the state of the evidence available to the project, and the later state from which reproduction is attempted. Conflating these layers creates hindsight substitution. Evidence discovered later can be useful for reassessment, yet it should not silently enter a reproduction of the earlier analysis. Likewise, categories stabilized later should not be projected backward as though they were available or meaningful in the same form during the original inquiry.

Definition 9.306 (As-of reconstruction protocol). *An as-of reconstruction protocol specifies the evidential, categorical, model, contextual, and uncertainty state that a historical reproduction seeks to recover at a defined project time, together with rules governing which later information may be used for reconstruction and which must remain analytically separated as retrospective knowledge.*

The protocol permits two related operations. The first reconstructs the earlier state as faithfully as the surviving record allows. The second compares that state with later evidence and interpretations. Keeping the operations separate preserves the epistemic difference between what was warranted then and what can be warranted now.

Historical reconstructability is not identical to replaying history. Field encounters cannot be recreated, institutions change, participants' memories evolve, archives ac-

quire new organization, and later consequences alter salience. The target is therefore the project's epistemic configuration rather than the literal recurrence of past conditions.

This distinction matters for evaluation. An earlier interpretation can be reasonable under the evidence then available and later become untenable after new records emerge. Reconstructability allows the project to describe that change without either protecting the earlier conclusion from revision or judging the earlier investigators as though they possessed later evidence.

Proposition 9.307 (Temporal epistemic separation). *Historical reproduction should preserve the distinction between the earlier project's as-of epistemic state and later retrospective knowledge whenever collapsing those states would alter evaluation of the evidence, categories, models, or judgments available to the original inquiry.*

The proposition also applies within a long-running project. A model selected in year one can be evaluated differently after year four, yet the project should remain able to reconstruct why it was selected under the earlier evidence. Longitudinal reproducibility therefore depends on temporal versioning as much as on file preservation.

9.19.6 Reproducibility under Changing Data

Many research datasets are not fixed objects. Administrative databases are corrected, longitudinal panels add waves, archives digitize new materials, web platforms change content, sensors continue recording, registries revise classifications, and living reviews incorporate new studies. Reproducibility under changing data requires explicit treatment of data vintage and update relations.

A first distinction separates *frozen reproduction* from *update-aware reproduction*. Frozen reproduction reruns the analysis from the same data state used in the earlier result. Update-aware reproduction applies a preserved analytical pathway to a later data state or determines how the earlier claim changes after the record evolves. Both are useful, but they answer different questions.

Definition 9.308 (Version-aware data reproduction). *Version-aware data reproduction* preserves the identity and provenance of the data state used in an earlier analysis and specifies how later data states are related to it, allowing discrepancies to be attributed to data evolution, analytical change, or their interaction.

The update relation can include appended observations, corrected values, changed identifiers, revised sampling frames, altered access rules, or source deletion. A project should record whether later data are supersets, corrections, transformations, or semantically changed records rather than treating all new versions as simple additions.

Live data systems create a special problem. A query executed later can return a different corpus even when the query text is identical. Reproducibility then depends on snapshotting where feasible or preserving query time, source version, retrieval parameters, and enough returned material or identifiers to reconstruct the earlier corpus under legitimate access conditions. When snapshotting is legally, ethically, or technically impossible, the limitation should be represented in the reproduction

profile.

Data evolution can itself become analytically informative. If the same model produces different conclusions after a new wave, the discrepancy may reflect genuine historical change rather than instability. If a corrected dataset reverses an estimate, the earlier result may have been computationally reproducible and still require substantive revision. Version-aware reproduction prevents these cases from being conflated.

Proposition 9.309 (Data-vintage attribution). *When a research result depends on an evolving data source, reproducibility requires preservation of the data state or sufficient version identifiers to recover it, together with an explicit account of how later data states differ and how those differences affect the reproduced claim.*

This proposition connects reproducibility to sensitivity analysis. A change across data vintages can be incorporated into a structured sensitivity profile when multiple plausible or historically relevant data states exist. It also connects to historical re-epistemization because later data can transform the standing of an earlier claim without erasing the conditions under which that claim originally appeared warranted.

9.19.7 Reproducibility under Changing Categories

Categories can change even when files and observations remain available. Legal statuses are redefined, occupational classifications are revised, institutional roles shift, diagnostic or administrative categories change, social identities acquire different public meanings, and a research project can itself revise concepts after encountering evidence. Reproduction under category change therefore requires attention to semantic lineage in addition to technical lineage.

Literal recoding is not always the strongest form of reproduction. Applying an obsolete category mechanically to later evidence can preserve syntax while changing meaning. Conversely, translating an earlier category into a later one can improve substantive comparability while introducing interpretive judgment. The reproduction profile should therefore state whether the aim is literal category reproduction, semantic translation, or comparative reconstruction across category regimes.

Section 9.15 introduced versioned categories and category bridges for historical re-epistemization. Reproducibility uses those structures to specify how claims travel across category versions. The bridge should record retained distinctions, merged distinctions, newly introduced distinctions, unresolved mappings, and the evidence used to justify translation.

Definition 9.310 (Category-sensitive reproduction). *Category-sensitive reproduction reconstructs an earlier analysis while preserving the versioned meaning of its categories and, where translation across category regimes is required, documents the bridge, losses, additions, ambiguities, and claim-scope changes introduced by that translation.*

This design is especially important when categories participate in the process being studied. An institutional classification can influence eligibility, resource access, recording practice, and later behavior. Changing the category then changes more than the researcher's description; it can change the relational reality represented by

the data. A crosswalk that treats categories as neutral labels can therefore obscure generative consequences of classification.

Category-sensitive reproduction also prevents false empirical disagreement. Two studies can appear to report different rates while using categories with different boundaries. Once the category bridge is reconstructed, part of the discrepancy may become semantic rather than empirical. The reverse can also occur: superficially identical labels can conceal changed meanings, making apparent agreement misleading.

Proposition 9.311 (Semantic-lineage preservation). *When a reproduced claim depends materially on categories whose meaning, boundary, or institutional function has changed, the reproduction architecture should preserve category version and translation lineage strongly enough to distinguish substantive change from semantic or classificatory change.*

The proposition supports both historical and cross-domain work. Reproduction across periods, institutions, languages, or disciplinary traditions often requires translation among partially overlapping categories. Explicit semantic lineage allows the project to preserve non-equivalence where translation remains incomplete.

9.19.8 Scope Conditions and Boundaries of Reproduction

Reproducibility is a powerful research quality, yet its meaning remains bounded by the nature of the research object and the ethical, historical, material, and epistemic conditions of inquiry. A project should therefore state the scope of a reproduction claim rather than converting successful reconstruction of one layer into a global judgment about the research.

Several boundaries are recurrent. Unique historical events cannot be repeated. Field relations can change because the researcher has already entered the setting. Participants can withdraw consent or become unavailable. Confidential or community-governed data can have legitimate access restrictions. Proprietary systems can prevent preservation of executable environments. Tacit skills can be only partly codified. Stochastic, chaotic, adaptive, or path-dependent processes can make exact output recurrence inappropriate even under highly similar conditions. Computational infrastructures can disappear. Research categories can become ethically or conceptually unacceptable for later reuse.

These boundaries do not automatically invalidate the inquiry. They change the level at which reproducibility should be claimed. A project can preserve documentary and interpretive reconstructibility when source redistribution is restricted. It can preserve an analytical contract when an exact software environment is lost. It can preserve a historical as-of state even though the original field encounter cannot recur. It can publish synthetic or controlled-access verification materials when raw data cannot be shared.

Definition 9.312 (Scope-explicit reproduction claim). *A scope-explicit reproduction claim states the research object and layer reproduced, the conditions preserved, the permissible substitutions or changes, the correspondence criterion achieved, the conditions that remain unavailable or non-reproducible, and the inferential conclusions*

that the reproduction does and does not support.

This definition prevents several overextensions. Computational reproducibility does not establish empirical truth. Documentary reproducibility does not establish analytical adequacy. Analytical reproducibility does not establish transportability to another field or period. Interpretive transparency does not guarantee interpretive convergence. Historical reconstructability does not make the past fully recoverable. Reproduction under changing data or categories does not eliminate the need to analyze why those changes occurred.

A second boundary concerns resource proportionality. Reproducing every intermediate operation can impose substantial storage, maintenance, labor, privacy, and coordination costs. Projects should prioritize high-consequence pathways, high-risk transformations, key claims, and objects likely to support later reuse or revision. Section 9.18 established selective traceability as the documentary principle; the same proportionality applies here. Reproduction architecture should preserve enough resolution to answer the relevant epistemic and governance questions without assuming that maximal technical capture is always desirable.

A third boundary concerns independence. Rerunning the same code on the same environment tests a different property from independently rebuilding the analysis from the documented specification. Both can be valuable. The former tests executable recurrence; the latter can expose hidden assumptions or underspecification. A mature project records which form was tested rather than using a broad reproducibility label for both.

Proposition 9.313 (Layer-specific reproduction warrant). *Evidence that one research layer has been successfully reproduced strengthens warrant only for the dependencies that the reproduction test actually exercises; stronger conclusions require separate justification across the additional evidential, analytical, interpretive, historical, or contextual layers on which the claim depends.*

The proposition makes reproducibility part of the uncertainty and robustness architecture rather than a substitute for them. Successful reproduction can reduce uncertainty about execution or lineage while leaving model uncertainty, historical uncertainty, category uncertainty, or normative uncertainty largely unchanged. Reproduction failure can reveal a fragile dependency, yet diagnosis is required before the project determines whether the failure weakens the substantive claim.

The completed architecture can be represented as a reproducibility matrix linking consequential claims to the layers on which they depend. For each claim, the matrix can record the computational pathway, documentary path, analytical contract, interpretive record, historical state, data version, category version, reproduction status, known limitations, and conditions for rerun or independent reconstruction. The matrix need not become a bureaucratic artifact for every minor output. Its value lies in making the reproducibility standing of consequential claims explicit and heterogeneous.

Reproducibility therefore concerns disciplined recoverability: rerunning executable pathways, reconstructing inferential ones, identifying change, and stating the remaining boundaries. This architecture prepares Section 258, which turns from recovery of an earlier project to reuse of preserved research objects.

9.20 Reusability

Section 9.19 developed reproducibility as disciplined recovery of an earlier research pathway. The present section turns to a different project-design problem: how research objects can enter later inquiries and become productive under new questions, methods, cases, scales, historical periods, or institutional settings. Its role is to specify the conditions under which reuse preserves epistemic continuity while permitting justified transformation. The objective is to organize reuse across data, code, models, concepts, relational maps, historical materials, and negative results, then to state how reuse should be reassessed when context changes. The method is relational and version-sensitive. A reusable object is treated as an object-with-lineage whose meaning and warrant depend partly on the relations through which it was produced, interpreted, governed, and transferred.

Reusability therefore concerns more than technical portability. A file can be copied while its evidential meaning becomes unstable. Code can execute in a new environment while the new research target differs from the one for which the procedure was designed. A model can retain its equations while the interpretation of its variables changes. A concept can preserve its label while its scope, contrasts, or normative loading drift. A relational map can preserve nodes and edges while the represented field changes historically. A negative result can remain correctly documented while losing force under a new measurement regime. Reuse is consequently a new inferential act that inherits an earlier research object and places it inside a new configuration of questions, evidence, assumptions, methods, governance, and uncertainty.

Definition 9.314 (Research-object reuse). *Research-object reuse* is the documented incorporation of a previously produced research object into a new inquiry in which its provenance, source state, relevant semantics, inherited assumptions, contextual dependencies, transformations, governance conditions, and required revalidation remain sufficiently explicit to evaluate the warrant of the new use.

Definition 9.314 places continuity and transformation inside the same architecture. Reuse can preserve an object nearly unchanged, adapt it for a neighboring setting, combine it with additional materials, or transform it into a derivative research object. Each pathway can be legitimate when the relation between the source and reused state remains reconstructible.

A project-level mechanism for organizing that relation is a reuse contract.

Definition 9.315 (Reuse contract). A *reuse contract* records the source object and version, intended function in the new inquiry, inherited assumptions and contextual dependencies, permissible transformations, required verification or revalidation, governance and access conditions, provenance links, and the identity of any derivative object created through reuse.

The term *contract* identifies an explicit research specification rather than a legal form. Its purpose is to prevent portability from silently expanding epistemic scope. A lightweight contract can accompany a minor code library or a well-characterized public dataset; a consequential cross-domain model transfer can require a substantially richer assessment. Materiality, uncertainty, potential harm, and inferential consequence should determine the depth of the record.

Table 9.11: Research objects and project-level conditions for reuse

Object	Continuity to preserve	Project-level reuse requirement	Characteristic drift risk
Data	Provenance, vintage, variable semantics, collection relations	Reassess fitness, permissions, transformations, missingness, and target population or field	Measurement and context drift
Code	Algorithmic function, dependencies, interfaces, tests	Preserve executable lineage and revalidate the research meaning of inputs, outputs, and assumptions	Executable portability with analytical mismatch
Model	Target relation, structure, parameter semantics, evaluation history	Reassess model–target correspondence, calibration, sensitivity, and scope	Transfer of hidden structural assumptions
Concept	Definition, contrasts, scope, revision history	Record semantic continuity, translation, modification, and domain-specific remainder	Label continuity with conceptual drift
Relational map	Node and edge semantics, boundary, scale, time, evidence	Specify whether the map is extended, compared, overlaid, or reinterpreted	Reification and false relational comparability
Historical material	Provenance, archival context, selection, classification history	Preserve source context while documenting new extraction, coding, or interpretation	Decontextualization and retrospective compression
Negative result	Tested expectation, conditions, inferential resolution, diagnosis	Reassess which constraint or boundary condition remains portable	Generalization of a bounded absence or failure

Table 9.11 summarizes the principal reuse objects developed below and the forms of continuity that each requires.

Proposition 9.316 (Reuse–revalidation coupling). *The evidential or analytical warrant of a reused research object depends on both the quality of its preserved lineage and the adequacy of revalidation for the function and context assigned to it in the new inquiry.*

Proposition 9.316 makes reuse an extension of the sensitivity, robustness, uncertainty, documentation, and reproducibility architectures developed earlier in the chapter. Preservation makes inheritance possible; revalidation determines how much of the earlier warrant travels with the object.

9.20.1 Reusable Data

Data are frequently reused because their collection can be costly, historically unique, ethically burdensome, or impossible to repeat. Reuse can enlarge the return from an

existing evidential resource and permit questions that were absent from the original study. The project-level challenge is to determine whether the relation between the preserved observations and the new inferential target remains adequate.

The data architecture developed in Section 9.7 already requires provenance, versioning, transformation history, governance, and preservation. Reusability adds a prospective question: which of those properties must be re-examined when the data serve a new purpose? A dataset assembled for descriptive monitoring may later be used for causal comparison; administrative records may become material for historical analysis; interview transcripts collected around one problem can later illuminate an unanticipated relational process. The new purpose can change which aspects of provenance become consequential.

A data reuse assessment should therefore begin with the source data state. Relevant information can include collection period, sampling or inclusion relations, measurement instruments, variable definitions, coding rules, missingness, transformations, uncertainty, access permissions, and known changes in the institutional environment. The assessment then specifies the new research function and identifies which source conditions remain compatible with that function.

Definition 9.317 (Data reuse assessment). *A data reuse assessment is a project record that links a preserved data version to a new research function and evaluates the provenance, semantic continuity, population or field relation, transformation history, uncertainty, governance conditions, and additional validation required for that use.*

Definition 9.317 also clarifies why access and reusability are distinct. Data can be openly downloadable yet poorly reusable because variable histories, selection processes, or transformations are obscure. Conversely, restricted data can support rigorous reuse through governed access when provenance and interpretive conditions are strong.

Data reuse should preserve the identity of derived states. Cleaning, harmonization, imputation, recoding, linkage, aggregation, translation, or feature construction can create a new data object even when the source observations remain unchanged. The derivative should retain a link to the source version while receiving its own version, transformation record, and uncertainty profile. This principle is especially important when several later projects build on the same base dataset and progressively transform it in different directions.

Proposition 9.318 (Data-reuse fitness). *A preserved dataset supports a new research use when the relations through which the relevant observations were produced remain sufficiently compatible with the new inferential target, or when consequential incompatibilities are identified, modeled, bounded, or carried forward as uncertainty.*

The proposition treats reuse fitness as claim-relative. One dataset can be suitable for reconstructing institutional chronology while remaining weak for estimating individual-level effects. Reuse decisions should therefore attach to the new claim rather than to a global property of the dataset.

9.20.2 Reusable Code

Code is a distinctive research object because it can encode both computational procedures and analytical decisions. Reusable code can shorten implementation time, expose earlier procedures to inspection, and create common infrastructure across projects. Its executability can also create an appearance of transferability that exceeds its research meaning. A function that runs correctly may still implement definitions, transformations, thresholds, or assumptions that are unsuitable for the new inquiry.

Code reuse therefore has at least two layers. The first is executable continuity: source version, software environment, dependencies, input and output specifications, tests, stochastic controls where relevant, and known failure conditions. The second is analytical continuity: the relation between the implemented operation and the concept, measurement, model, or inferential procedure that the operation is supposed to realize.

Definition 9.319 (Code reuse envelope). A *code reuse envelope* specifies the executable and analytical conditions under which a preserved code object can be incorporated into a new research workflow, including version, dependencies, interfaces, test conditions, implemented assumptions, linked research objects, known failure modes, and required validation after modification or transfer.

The envelope can distinguish several forms of reuse. Direct reuse applies an unchanged implementation under materially similar conditions. Configurational reuse changes parameters or inputs while preserving the computational procedure. Adaptive reuse modifies code to fit a new data structure, model, or context. Library reuse extracts a general-purpose component whose research meaning is largely independent of the original project. These modes create different verification burdens.

Modification should produce an explicit derivative identity when the implemented analytical meaning changes. A corrected bug, new preprocessing rule, changed optimization routine, revised classification threshold, or altered convergence criterion can change downstream results while leaving much of the codebase visually similar. Versioning therefore supports epistemic traceability as well as software maintenance.

Proposition 9.320 (Executable portability and analytical validity). *Successful execution of reused code establishes a property of the computational pathway under the tested environment; analytical validity in a new inquiry additionally requires correspondence between the implemented operation and the concepts, data, models, and inferential purposes of that inquiry.*

This distinction also applies to AI-generated or AI-modified code. Section 9.16 requires role-sensitive verification and dependency tracking for AI-assisted operations. Reuse should preserve that lineage when generated components enter later workflows, because apparent modularity can hide common upstream dependencies.

9.20.3 Reusable Models

Models can be reused as analytical structures, computational implementations, comparison objects, priors for model development, or components in broader model families. Earlier sections have already required model provenance, model–evidence di-

alogue, sensitivity analysis, and robustness assessment. Reusability integrates these records around a new question: which parts of the model's earlier warrant remain informative after the model is transferred?

A model contains several potentially portable layers. Its formal structure can travel independently of a particular calibration. Parameter meanings can remain stable while estimated values change. A mechanism can remain useful as a hypothesis while a complete model becomes unsuitable. A model family can remain productive even when one specification fails in the new setting. Project design should identify which layer is being reused.

Definition 9.321 (Model transfer assessment). *A model transfer assessment evaluates a reused model's target relation, conceptual interpretation, structural assumptions, state variables, parameter semantics, boundary and initial conditions, calibration history, sensitivity profile, evaluation record, and contextual dependencies against the requirements of the new inquiry.*

The assessment can result in direct use, recalibration, structural adaptation, category revision, restriction to a narrower claim, retention as a comparison model, or replacement. These outcomes need not be interpreted as success and failure states of the original model. They indicate how model adequacy changes with the target relation.

A central risk is inherited precision. A model that was well calibrated in one setting can carry numerical specificity into another setting where its structural assumptions are less secure. Recalibration alone can then conceal deeper mismatch. Section 9.11 established a revision hierarchy from parameters through structure, categories, methods, theory, and model replacement. Model reuse should preserve access to that hierarchy rather than defaulting to parameter adjustment.

Proposition 9.322 (Model-target revalidation). *Reuse of a model in a new inquiry requires renewed evaluation of the model–target relation at the level actually transferred; earlier calibration or validation can inform this evaluation while remaining conditional on the continuity of relevant structures, meanings, and boundary conditions.*

The proposition permits cumulative modeling without treating models as context-free instruments. Reuse can become especially informative when transfer fails in a well-diagnosed way, because the failure can reveal which structural relation differs between contexts and can motivate a richer model family in Section 259.

9.20.4 Reusable Concepts

Concepts often travel farther than datasets or models. They move across projects, disciplines, languages, institutions, and historical periods, sometimes becoming organizing terms for research programmes. Chapter 6 established that responsible conceptual reuse requires preservation of definition, scope, contrasts, and revision history. Integrated research design adds a translation problem: a project should specify what semantic continuity it claims when a concept enters a new inquiry.

Label continuity provides weak evidence of conceptual continuity. Terms such as *value*, *institution*, *power*, *trust*, *capacity*, or *relation* can carry distinct theoretical, empirical, and normative roles across research traditions. Even within one programme,

a concept can change scale or analytical function. A relational concept developed for organizational analysis may require modification before it is applied to an international, ecological, or computational field.

Definition 9.323 (Concept reuse translation record). A *concept reuse translation record* identifies the source definition and scope of a reused concept, the function assigned to it in the new inquiry, properties treated as continuous, properties modified or suspended, relevant contrasts, historical or domain-specific differences, and unresolved semantic remainder.

This record permits graded continuity. Some reuse is definitional: the source definition is intentionally preserved. Some is analogical: selected relational features are carried across domains while other properties remain distinct. Some is developmental: the new project revises the concept and creates a derivative version. Some is comparative: competing concepts are placed side by side without synthesis. Section 9.10 already established that irreducible disagreement can be preserved; conceptual reuse should retain that option.

The record is particularly important for GR and GRE because the programme deliberately engages multiple domains while maintaining ontological suspension and disciplinary restraint. Cross-domain portability should therefore be demonstrated at the level of specified structural relations rather than inferred from common vocabulary.

Proposition 9.324 (Semantic continuity under reuse). A *reused concept supports cumulative comparison when the project makes explicit which semantic and structural properties are treated as continuous, which are transformed, and which remain unresolved across the source and receiving inquiries.*

Semantic continuity can therefore coexist with theoretical development. The important project-level condition is traceable transformation: later readers should be able to determine whether two uses instantiate one stable concept, neighboring versions, an analogy, or a contested translation.

9.20.5 Reusable Relational Maps

Relational maps are especially reusable within GRE because they can become layers in longitudinal analysis, templates for comparison, inputs to formal models, guides for field inquiry, or records of competing interpretations. Their apparent visual continuity also creates a distinctive risk. Similar nodes and edges can conceal changes in edge semantics, boundary rules, scale, observation, or historical context.

A project should therefore state the operation being performed on a reused map. Extension adds entities, relations, evidence, or time points to an existing representation. Comparison places maps from different cases or periods into a common analytical frame. Overlay combines distinct relation types or evidential layers. Translation converts one representational scheme into another. Reinterpretation changes the meaning assigned to represented structures. These operations differ in what kinds of correspondence they require.

Definition 9.325 (Relational-map reuse specification). A *relational-map reuse specification* records the source map version, represented entities and relation types,

edge semantics, boundary, scale, temporal index, evidential sources, uncertainty, intended reuse operation, correspondence rules, and any transformations introduced in the receiving inquiry.

Map reuse also requires attention to observational asymmetry. A relation absent from an earlier map can reflect genuine absence, unobservability, source loss, boundary choice, or a category that was unavailable to the earlier inquiry. Later extension should therefore preserve the distinction between newly generated relations and newly observed or newly representable relations where the evidence permits it.

Alternative maps can remain reusable as competing representations. Section 9.10 treats preservation of competing interpretations as a legitimate adjudicative outcome. A later project can compare these maps against new evidence without first collapsing them into a single representation.

Proposition 9.326 (Relational correspondence in map reuse). *Comparative or cumulative reuse of relational maps requires explicit correspondence at the level of entities, relation semantics, boundary, scale, time, and evidential status relevant to the comparison; visual or nominal similarity alone provides insufficient warrant for relational equivalence.*

The proposition turns map reuse into a structured comparison problem. When correspondence fails, the mismatch can itself become evidence of historical transformation, scale dependence, category change, or altered observability.

9.20.6 Reusable Historical Materials

Historical materials can acquire new research value long after their original collection. Archival documents, administrative records, correspondence, fieldnotes, photographs, oral histories, earlier datasets, model outputs, and institutional records can be revisited under new questions or analytical tools. Section 9.15 developed historical re-epistemization as preservation of temporal epistemic optionality. Reusability specifies how a later project should turn preserved materials into a new evidential object while retaining the source context needed for responsible interpretation.

Historical reuse should distinguish the preserved source from later analytical transformations. Digitization, transcription, translation, coding, entity extraction, linking, summarization, or computational representation can enlarge accessibility and analytical range. Each operation can also alter what becomes visible, searchable, comparable, or salient. The transformed object therefore benefits from a derivative identity linked to the underlying material.

Definition 9.327 (Historical-material reuse record). *A historical-material reuse record links a preserved historical source or collection to its provenance, archival and institutional context, original classificatory conditions, known selection and absence patterns, access or stewardship conditions, later transformations, and the evidential function assigned to it in a new inquiry.*

The record supports reinterpretation without implying that historical meaning is fixed by the original archive. Later researchers can legitimately ask different questions, combine sources differently, or recognize relations that earlier investigators

could not articulate. Historical re-epistemization becomes stronger when such reinterpretation remains distinguishable from silent decontextualization.

Later historical consequences can also change salience. An earlier memorandum, minor institutional change, peripheral actor, or apparently failed initiative can become important once a later trajectory reveals its connections. Section 9.15 distinguished retrospective salience from retrospective determination. The same distinction should govern reuse: later significance can reorganize inquiry while preserving uncertainty about what earlier actors could know and what trajectories remained open at the time.

Proposition 9.328 (Context-preserving historical reuse). *Historical materials can support new interpretations when later analytical transformations remain traceable to the preserved source and its historical production context, allowing new questions to alter evidential organization without erasing the conditions under which the source originally existed.*

This principle is especially important for AI-assisted historical research. Machine extraction or synthesis can enlarge encounter surfaces across large archives, while the reusable research object remains the source-linked material and transformation lineage rather than the generated summary alone.

9.20.7 Reusable Negative Results

Negative results can become reusable research objects when their diagnostic content is preserved. Section 9.18 established a negative-result record containing the tested expectation, conditions, procedure, uncertainty, interpretation, and constrained claims. Reusability asks what later inquiries can legitimately inherit from that record.

Several forms of reuse are possible. A negative result can narrow a plausible mechanism space, identify a boundary condition, warn against an ineffective measurement strategy, motivate a deviant-case design, constrain a model family, or justify a new test under changed conditions. A null or contrary result can also become historically informative when institutions, technologies, or categories later change in ways that alter the expected relation.

Definition 9.329 (Negative-result reuse profile). *A negative-result reuse profile specifies the expectation previously tested, the conditions and inferential resolution of the test, the diagnostic interpretation assigned to the result, the claims or pathways it constrained, and the dimensions of continuity or change relevant to a proposed later use.*

This profile guards against two opposite errors. The first treats a bounded negative finding as a context-free prohibition on future inquiry. The second ignores an informative earlier failure and repeats substantially the same design without explanation. Responsible reuse locates the earlier result within the new question.

Negative results can also support methodological economy. A later project can avoid repeating a demonstrably uninformative operation when the relevant conditions remain stable, or can deliberately repeat it when improved measurement, a new case, a changed historical context, or a stronger identification strategy alters the

evidential situation. The reuse record should make that difference explicit.

Proposition 9.330 (Conditional portability of negative results). *The constraining force of a negative result transfers to a later inquiry in proportion to the continuity of the tested expectation, relevant conditions, measurement and inferential resolution, and the claims to which the earlier diagnosis applied.*

Negative results therefore contribute to cumulative inquiry through conditional constraint rather than permanent closure. Their future value can increase when the project preserves enough structure to distinguish repeated failure from a genuinely new test.

9.20.8 Reuse under Context Change

Context change is the integrative problem of reuse. Data, code, models, concepts, maps, historical materials, and negative results each carry dependencies that can become more or less consequential when the receiving inquiry differs from the source project. The final task of reuse architecture is therefore to make contextual change explicit enough that continuity, adaptation, and transformation can be distinguished.

Relevant context can include population or field composition, institutional rules, historical period, technological infrastructure, spatial and temporal scale, data-generation systems, language, category regimes, governance arrangements, power relations, environmental conditions, and normative frameworks. The appropriate dimensions are object- and claim-relative. A change in software infrastructure can dominate code reuse while remaining peripheral to a conceptual comparison. A legal reclassification can alter administrative data semantics while leaving some physical measurements unchanged. A historical transition can transform the meaning of a relational map even when its formal graph structure remains similar.

Definition 9.331 (Context-change reuse assessment). *A context-change reuse assessment identifies the contextual dimensions relevant to a proposed reuse, compares their source and receiving states, specifies which continuities are relied upon, records consequential differences, and determines the preservation, revalidation, adaptation, reinterpretation, or replacement required for the reused object.*

The assessment supports several reuse trajectories. *Preservational reuse* carries an object into a materially similar context with limited transformation. *Transported reuse* preserves the main object while requiring validation against a new case or setting. *Adaptive reuse* changes part of the object or its implementation while retaining a traceable core. *Transformative reuse* creates a derivative object whose relation to the source remains historically and conceptually important even though direct equivalence is no longer claimed. These trajectories can coexist within one project across different research objects.

Context change also interacts with uncertainty. A reused object can have strong provenance and still acquire substantial uncertainty when its new target differs from the original one. Section 9.14 provides the architecture for carrying such uncertainty forward. Sensitivity analysis in Section 9.12 can identify which contextual differences materially affect the result, while robustness analysis in Section 9.13 can determine which conclusions remain stable across justified reuse conditions.

Derivative identity becomes especially important under substantial adaptation. If a model is structurally modified, a concept receives a new scope, a dataset is extensively harmonized, or a relational map is reclassified under new edge semantics, the receiving project should preserve the source lineage while assigning the derivative its own version and warrant. This prevents cumulative research from compressing a trajectory of transformations into an apparent sequence of identical objects.

Proposition 9.332 (Context-sensitive reuse warrant). *A reuse claim is strengthened when the project identifies the contextual continuities on which transfer depends, the differences that can alter meaning or performance, and the revalidation or transformation through which the receiving inquiry establishes its own warrant.*

A practical project can summarize these relations in a reuse register. For each consequential research object, the register can record source version, receiving use, reuse trajectory, inherited assumptions, contextual differences, transformations, revalidation status, governance conditions, uncertainty, derivative identifier, and downstream claims. Such a register complements the documentation architecture in Section 9.18 while remaining prospective: documentation reconstructs how an object came to exist, whereas the reuse register records how the object is deliberately carried into another inquiry.

Reusability thus converts preservation into future research capacity. Research objects become generative resources when later investigators can inherit them with enough lineage to understand what travels, enough flexibility to transform what should change, and enough discipline to establish new warrant where context differs. The next section turns from reuse of individual research objects to the larger architecture through which repeated reuse, comparison, replication, reinterpretation, and revision can accumulate into a research programme.

9.21 Cumulative Research

Sections 9.15–9.20 established the conditions under which a research project can preserve its historical states, govern consequential decisions, document its lineage, support reproduction, and make selected research objects reusable. The present section moves from the integrity of one project to the architecture through which multiple projects can become a cumulative research programme. Its role is to specify how results, concepts, evidence, models, comparisons, replications, reinterpretations, and revisions can enter shared trajectories without being flattened into a single vocabulary, metric, method, or theory. The objective is to define project-level structures that allow later inquiries to inherit earlier work while retaining provenance, disagreement, boundary conditions, and the possibility of correction. The discussion proceeds through research programmes, shared vocabulary, shared evidence, model families, comparative accumulation, replication, reinterpretation, theoretical revision, and intergenerational research memory. The method is relational and historical: cumulation is treated as an organized relation among research objects and research communities across projects and time, rather than as a scalar increase in publications or stored results.

The need for such an architecture follows from the heterogeneity of the preced-

ing chapter. A project may produce historical interpretations, relational maps, statistical estimates, formal models, simulation results, mechanism claims, intervention evidence, uncertainty profiles, negative results, or revised categories. These outputs do not accumulate by the same operation. Some can be compared directly; some require translation; some become informative through disagreement; some remain locally valid while limiting a broader theory; and some become valuable only after later evidence changes their significance. A cumulative design therefore requires relations among outputs rather than a presumption that outputs are commensurable units.

This position also separates cumulation from simple retention. Preservation makes earlier objects available; reusability makes selected objects transportable under explicit conditions; cumulative research additionally organizes how successive projects change the standing of claims and research possibilities. An accumulation can strengthen a claim, narrow its domain, divide one category into several, expose a previously hidden dependency, replace a model family, preserve an unresolved disagreement, or transform the question itself. Growth in the programme can therefore include contraction, differentiation, abandonment, and reopening.

Definition 9.333 (Cumulative research architecture). A *cumulative research architecture* is a governed and versioned arrangement through which research projects preserve and relate concepts, evidence, models, comparisons, replications, interpretations, revisions, and unresolved questions so that later inquiry can determine what has been retained, strengthened, qualified, contested, transformed, or reopened.

Definition 9.333 places change of epistemic standing at the center of cumulation. The architecture is therefore claim-relative and object-relative. It does not require every project to contribute to every programme object. It requires consequential contributions to remain sufficiently connected to the earlier materials, categories, methods, and disagreements that give their contribution meaning.

Table 9.12 summarizes the principal cumulative objects developed in this section and the continuity each requires.

9.21.1 Research Programmes

A cumulative research programme requires enough continuity for separate projects to become mutually informative. Continuity can arise through shared problems, recurring objects, compatible records, inherited concepts, comparable cases, model lineages, replication relations, or explicit theoretical disagreement. It does not require doctrinal uniformity. Indeed, the methodological pluralism developed earlier in the book makes productive disagreement one possible mode of programme continuity. What matters is that projects can identify their relation to a wider trajectory rather than appearing as isolated contributions whose terminology and evidential standing must be reconstructed from the beginning.

Research programmes also have histories. Problems that once appeared central can become peripheral; methods can change; evidence standards can tighten; categories can divide; technologies can create new observable objects; and institutional changes can make earlier assumptions untenable. Kuhn's historical account is relevant here because scientific communities organize problems and standards through

Table 9.12: Project-level architecture for cumulative research across inquiries

Cumulative object	Required continuity	Primary programme function	Characteristic failure
Vocabulary	Definition, scope, contrasts, version, translation	Comparable questions and explicit conceptual revision	Silent semantic drift
Evidence	Provenance, target claim, method, context, uncertainty	Cross-project evidential synthesis and conflict diagnosis	Decontextualized pooling
Model family	Assumptions, structure, target, lineage, variants	Structured comparison and model revision	Variant proliferation without lineage
Comparative record	Case relation, dimensions, boundary, translation	Accumulation of similarities, differences, and boundary conditions	False comparability
Replication	Preserved and varied conditions, claim, correspondence test	Diagnostic testing beyond the original project	Binary success–failure labeling
Interpretation lineage	Earlier reading, new context, trigger, evidence	Historical re-epistemization and conceptual reopening	Retrospective erasure
Theory revision	Trigger, retained structure, changed commitments, consequences	Programme-level correction and theoretical development	Additive theory without contraction
Research memory	Provenance, stewardship, access, unresolved alternatives	Intergenerational continuity and future option value	Storage without epistemic recoverability

inherited practices that can themselves change (Kuhn 1962). GRE uses this historical sensitivity without requiring a single model of scientific change. A programme can develop through gradual clarification, branching, hybridization, contraction, or more discontinuous reorganization.

The project-level question is therefore how one inquiry declares and preserves its programme relation. A project should be able to state which shared problems it addresses, which inherited objects it uses, which earlier claims or models it tests, which definitions it modifies, and which programme records should change if its conclusions are accepted. This statement is more informative than a general declaration of disciplinary membership because it specifies the path through which the project can alter cumulative knowledge.

Definition 9.334 (Programme contribution relation). A *programme contribution relation* specifies how a research project connects its questions, objects, evidence, models, findings, or revisions to one or more existing programme objects and identifies the cumulative change that the project is positioned to support.

The contribution relation can take several forms. A project can extend an earlier finding to a new domain, qualify it through a boundary condition, test it through replication, provide a competing interpretation, revise a category, introduce a model variant, contribute new evidence to an existing dispute, or reopen a question that had been treated as settled. Some projects may create a new branch whose relation to the

existing programme remains provisional. Recording that provisionality is preferable to forcing premature integration.

Programme architecture should also preserve negative relations. A study can show that a GRE concept adds little in a domain where an established theory already performs adequately. A replication can weaken an earlier mechanism claim. A comparative study can show that a supposed cross-domain regularity was produced by category translation. Such contributions narrow the programme's domain and can improve its precision. Cumulative development therefore concerns disciplined change in what the programme has reason to claim, investigate, or preserve.

Proposition 9.335 (Programme-relative cumulation). *A project contributes cumulatively to the extent that its relation to existing programme objects and the resulting change in their epistemic standing can be reconstructed, rather than merely from the addition of a new output to the literature.*

Proposition 9.335 provides the organizing principle for the remaining subsections. Vocabulary, evidence, models, comparisons, replications, interpretations, and revisions become cumulative when their relations across projects are made explicit enough to support inheritance and correction.

9.21.2 Shared Vocabulary

Shared vocabulary is one of the lowest-cost coordination devices available to a research programme, yet its apparent simplicity can be misleading. A common label can conceal incompatible meanings, while different labels can represent closely related distinctions. GRE therefore benefits from semantic coordination that preserves version, scope, neighboring concepts, and translation rather than assuming that lexical identity creates conceptual identity.

The project-level architecture can represent important concepts through a shared vocabulary registry. Each entry can record a preferred term, definition, version, intended analytical role, relevant contrasts, scale or domain restrictions, known contested uses, relation to earlier versions, and translations into neighboring vocabularies. The registry need not operate as a fixed ontology. Its purpose is to make semantic continuity and revision inspectable.

Definition 9.336 (Shared vocabulary registry). *A shared vocabulary registry is a versioned programme record that preserves the definitions, scopes, contrasts, disputed uses, translations, and revision relations of concepts used across multiple research projects.*

Such a registry supports at least three cumulative operations. First, it reduces accidental disagreement generated by unrecognized definition changes. Second, it permits deliberate disagreement to be localized: researchers can identify whether they dispute a term's extension, its mechanism, its normative loading, or its usefulness. Third, it makes conceptual evolution cumulative by allowing later projects to inherit a concept while recording how they narrow, broaden, divide, translate, or replace it.

Shared vocabulary should remain plural where the research object warrants plurality. Terms such as relation, field, value, institution, subject, capacity, power, generativity, or constraint can have domain-specific specifications. A legal relation, ecolog-

ical relation, financial relation, and educational relation need not be collapsed into one operational definition merely because GR provides a shared higher-level vocabulary. Programme coordination is strengthened when researchers can state which structural features they regard as shared and which domain-specific differences remain irreducible.

Vocabulary also interacts with evidence. A category can become standardized because a dataset, institution, or measurement infrastructure repeatedly uses it. That standardization can improve comparability while also stabilizing a historically contingent partition of the world. Versioned vocabulary therefore helps researchers distinguish continuity of a research convention from continuity of the underlying relational reality. Section 9.15 developed category bridges for historical re-epistemization; a programme registry generalizes that logic across projects.

Proposition 9.337 (Semantic continuity under programme reuse). *When multiple projects accumulate evidence under a shared term, the strength of cross-project inference depends partly on preserving enough semantic lineage to determine whether the relevant concept remained substantively comparable across those projects.*

This proposition makes semantic traceability part of evidential architecture. A large body of studies using the same label can remain weakly cumulative if the object denoted by that label shifts invisibly across periods, fields, or institutions.

9.21.3 Shared Evidence

Evidence becomes cumulative when later projects can determine what an earlier observation bears upon, how it was produced, and under which conditions it can enter a new inference. The phrase *shared evidence* therefore refers to more than public availability. Evidence shared across a programme requires relations among source, claim, method, context, uncertainty, and later use.

A shared evidence architecture can be represented as a network rather than a warehouse. Nodes can include evidence objects, claims, cases, methods, categories, models, and interpretations; relations can record support, challenge, dependence, translation, reuse, replication, or supersession. The purpose is not to assign one universal weight to every evidential object. It is to allow later projects to reconstruct why an object was treated as relevant and how its standing changed.

Definition 9.338 (Programme evidence relation). *A programme evidence relation records how a preserved evidential object bears upon a specified claim or research object under a documented method, context, category regime, uncertainty state, and project version.*

This definition prevents several forms of false accumulation. Pooling evidence across incompatible populations can create apparent precision while destroying the conditions under which the observations were meaningful. Combining historical records generated under different classifications can produce an artificial time series. Treating multiple model outputs derived from the same upstream dataset as independent evidence can exaggerate support. Conversely, evidence that appears contradictory can become mutually informative once differences in scale, boundary, category, or historical context are represented.

Shared evidence therefore benefits from dependency records. Section 9.16 emphasized dependency management for AI-assisted workflows; the same principle operates at programme scale. Several projects may cite different papers while ultimately depending on the same dataset, archival transcription, benchmark, model family, or institutional classification. A cumulative programme should be able to recognize such shared ancestry when assessing evidential diversity.

Evidence can also remain programme-relevant after its original claim is withdrawn. A measurement failure can inform later instrument design. A null result can establish a boundary condition. An archival source rejected for one interpretation can support another. The reuse contract developed in Section 9.20 therefore enters cumulative research through explicit evidence relations rather than through unrestricted evidential portability.

Proposition 9.339 (Dependency-aware evidential accumulation). *Cross-project evidential support is strengthened when the programme can distinguish genuinely differentiated evidential pathways from multiple outputs that share consequential upstream dependencies.*

The proposition does not imply that dependent evidence is valueless. Shared dependencies can be appropriate and sometimes unavoidable. The requirement is that dependence remain visible enough that evidential diversity is not inferred from surface multiplicity alone.

9.21.4 Model Families

Models frequently accumulate through families rather than isolated specifications. A baseline model acquires variants, extensions, alternative parameterizations, changed mechanisms, additional scales, new data links, or different normative assumptions. Without explicit lineage, this proliferation can make comparison difficult: two models can share a name while representing materially different structures, or carry different names while differing only superficially.

A model family architecture treats models as related research objects with ancestry and branching. The record can identify a parent specification, retained assumptions, introduced changes, target domain, calibration or estimation basis, empirical standing, sensitivity profile, and reasons for branching. Section 9.11 established model-evidence dialogue within a project; cumulative research extends that dialogue across projects by preserving how model variants respond to earlier failures, new evidence, or changed questions.

Definition 9.340 (Model family record). *A model family record is a versioned representation of related models that identifies their common structural ancestry, variant-specific assumptions and mechanisms, evidential targets, empirical or interpretive status, and the revisions that generated new branches.*

Families can contain competing as well as nested models. A later model does not automatically supersede an earlier one. An earlier specification can remain preferable for a narrower domain because it is more interpretable, requires fewer assumptions, or matches the available evidence more closely. Multiple-model reasoning from Section 9.11 therefore scales naturally into programme architecture: families preserve

alternative representations when the object remains underdetermined or different models illuminate distinct dimensions.

Model-family cumulation also supports structured falsification and contraction. When several variants fail under the same empirical condition, the failure can challenge a shared family assumption rather than each model independently. When one branch consistently succeeds only within a particular institutional setting, that setting becomes a candidate scope condition. When a new model changes the categories through which the target is represented, the family record should indicate that the branch is partly conceptual rather than merely technical.

Formal resemblance alone is insufficient for family membership. Two dynamical systems can use similar equations while representing different relational objects; two network models can use the same topology while assigning different semantics to edges; two agent-based models can share code structure while encoding incompatible behavioral assumptions. The family relation should therefore be defined by analytically relevant inheritance rather than by surface form.

Proposition 9.341 (Lineage-preserving model accumulation). *Model accumulation becomes more diagnostically informative when variants preserve explicit lineage connecting structural changes to the evidence, assumptions, questions, or failures that motivated those changes.*

Such lineage makes model families useful for theory development rather than merely for software organization. It allows later researchers to ask which revisions changed predictive or explanatory performance and which merely redistributed complexity.

9.21.5 Comparative Accumulation

Comparison is one of the principal mechanisms through which local findings can become programme knowledge. A single case can establish the plausibility of a mechanism or reveal a relation, but comparison helps determine which features travel, which depend on context, and which apparent similarities dissolve under closer specification. Comparative accumulation therefore concerns the progressive organization of similarities, differences, translations, and boundary conditions across cases and projects.

The cumulative unit should be richer than a list of cases. A comparative record can specify why cases are being related, which dimensions are treated as comparable, how categories are translated, what scales and time windows are aligned, which contextual differences are retained, and which claim is under comparative pressure. This design follows the case-selection architecture developed earlier in Chapter 9 while extending it beyond a single project.

Definition 9.342 (Comparative accumulation matrix). *A comparative accumulation matrix is a versioned programme record that relates cases or projects through specified comparison dimensions, category bridges, scale and boundary conditions, evidential standing, observed correspondences, observed differences, and unresolved translation problems.*

The matrix need not be literally tabular. Its analytical function is to prevent a com-

parative conclusion from becoming detached from the dimensions that generated it. A mechanism can recur across cases while its magnitude, timing, or mediating institutions differ. A relation can appear only above a particular scale. A concept can require translation because legal or organizational categories differ. Comparative accumulation records these structures so that later projects can select cases in relation to known variation rather than repeatedly rediscovering it.

Comparison can also accumulate through deviant cases. A case that violates a well-supported pattern can reveal an omitted condition, a measurement problem, a distinct mechanism, or a category error. The cumulative value of the deviant case depends on retaining its relation to the pattern it disrupted. Similar logic applies to boundary cases and negative cases. They contribute by reorganizing the domain of a claim rather than by adding another affirmative instance.

Cross-domain comparison requires additional caution. GRE's higher-level concepts are designed to travel across economics and neighboring fields, yet structural resemblance does not establish equivalence. Dependency in a labor relation and dependency in digital infrastructure can share features while differing in law, subjecthood, materiality, exit, temporality, or normative significance. Comparative accumulation should preserve these differences and allow partial correspondence to remain partial.

Proposition 9.343 (Boundary-producing comparison). *Comparative accumulation strengthens a research programme when comparison refines the scope, translation conditions, and boundary structure of claims in addition to identifying recurrent similarities.*

The proposition gives differences a positive cumulative role. A programme becomes more precise when it learns where a mechanism ceases to travel, which conditions alter it, and which apparently shared categories require differentiation.

9.21.6 Replication

Replication provides a deliberately structured relation between an earlier claim and a later inquiry. Section 9.19 distinguished reproduction from replication: reproduction primarily asks whether an earlier research pathway can be recovered or rerun, whereas replication places the substantive claim under a new research configuration whose similarities and differences are part of the test. Large coordinated replication efforts illustrate that replicability can itself become an empirical object of investigation (Open Science Collaboration 2015). Open research practices can reduce some material barriers to such work by improving access to data, materials, methods, and documentation (Nosek et al. 2015).

For a cumulative programme, the central design problem is to specify the replication relation. A close replication can preserve many features of the earlier configuration. A conceptual replication can alter operationalization while testing the same higher-level relation. A historical replication can revisit a claim under changed time conditions. A cross-context replication can test transportability across institutions, populations, infrastructures, or scales. These designs address different uncertainties and should not be collapsed into one binary outcome.

Definition 9.344 (Programme replication profile). *A programme replication profile identifies the earlier claim being tested, the research conditions intentionally preserved, the conditions intentionally varied, the correspondence criterion, the evidential question created by those choices, and the programme-level revision triggered by possible outcomes.*

The final element is important. Replication becomes cumulative when possible results have interpretable consequences for programme knowledge. A divergent result can reduce confidence in the original estimate, reveal context dependence, expose a measurement difference, identify historical change, or suggest that the replication failed to preserve a consequential relation. Diagnosis should precede theoretical revision. Conversely, a convergent result can strengthen a claim while leaving broader questions of mechanism, category adequacy, or transportability unresolved.

Replication series can themselves become comparative objects. When several replications vary different conditions, their pattern can reveal which dimensions matter. A mechanism that persists across institutions but changes across historical periods points toward a different boundary structure from one that varies by measurement instrument. Programme architecture should therefore preserve replication profiles jointly rather than treating each replication as an isolated vote.

Replication also has institutional conditions. Publication incentives can favor novelty over repeated testing, while standardized benchmarks can create repeated tests that are easy to count but narrow in scope. The cumulative value of replication depends on the question it addresses and the independence of its evidential pathway. A programme should therefore recognize replication as one research function among several rather than as a universal hierarchy over historical, interpretive, or otherwise non-repeatable inquiry.

Proposition 9.345 (Diagnostic replication accumulation). *A sequence of replications becomes cumulatively informative when preserved similarities and variations among replication conditions allow divergent and convergent outcomes to refine the dependency and boundary structure of the target claim.*

This proposition turns replication from a verdict into a structured source of comparative evidence.

9.21.7 Reinterpretation

Cumulative research can change because later investigators see earlier materials differently. New categories, theories, methods, political conditions, institutional reforms, technical capacities, or discovered evidence can alter the meaning of an archive, dataset, model, field note, or historical event. Section 9.15 developed historical re-epistemization as a preservation architecture; reinterpretation is one process through which that preserved temporal optionality becomes active.

Reinterpretation should preserve the earlier reading as an object of research history. Replacing an old interpretation in place can destroy evidence about why the earlier view appeared reasonable under its own epistemic conditions. A cumulative programme therefore benefits from versioned interpretation lineages that relate successive readings to the evidence, concepts, context, and methods available at each

stage.

Definition 9.346 (Interpretation lineage). An *interpretation lineage* is a versioned relation among successive readings of a preserved research object that records the earlier interpretation, the trigger for reopening it, newly available evidence or context, changed conceptual or methodological resources, retained elements, revised elements, and remaining disagreement.

This structure helps distinguish reinterpretation from correction of a clerical error. Reinterpretation can preserve the same source material while changing the inferential or historical frame through which it is understood. It can also reveal that the research object itself was partly constituted by categories that later changed. In such cases, the later interpretation need not simply dominate the earlier one; the relation between them can become evidence about historical change in institutions, concepts, or epistemic practices.

Reinterpretation is particularly important for heterogeneous evidence. An interview corpus can later become relevant to a question its original project did not formulate. Administrative data can acquire new meaning after legal reform reveals how earlier classifications operated. A model once treated as predictive can later be studied as evidence about a historical policy imagination. Such moves are legitimate only when the new use remains connected to the original provenance and does not project later categories backward without qualification.

Programme-level reinterpretation can also recover abandoned alternatives. Section 9.10 preserved competing interpretations after cross-method adjudication; later evidence may change their relative standing. The cumulative record should permit recovery without implying that every superseded interpretation remains equally plausible. Preservation and current warrant remain distinct.

Proposition 9.347 (Non-erasing reinterpretation). *Reinterpretation contributes cumulatively when a later reading can revise the standing of an earlier interpretation while preserving enough of the earlier epistemic state to reconstruct what changed and why.*

The proposition connects cumulative research to historical humility. Later knowledge can improve an interpretation while remaining historically situated and revisable in turn.

9.21.8 Theoretical Revision

A cumulative programme eventually changes its theoretical structures. Evidence can challenge a mechanism; comparison can expose a missing boundary condition; a model family can reveal an unstable assumption; reinterpretation can alter the meaning of an earlier case; and new domains can require distinctions unavailable in the inherited vocabulary. Theoretical revision is therefore one outcome of cumulative architecture rather than an exceptional disruption to it.

This subsection concerns the programme-level record of revision. Section 260 will examine theory development more directly within research praxis, including theory as both a condition and an output of inquiry. The present task is narrower: to specify how revisions generated across projects enter a cumulative history without making

each theoretical change appear either as a complete rupture or as an additive extension.

Definition 9.348 (Programme theory revision record). A *programme theory revision record* documents a consequential change in theoretical commitments by identifying the triggering evidence or problem, the earlier formulation, retained structures, modified or withdrawn claims, newly introduced distinctions, affected model or concept families, unresolved alternatives, and the downstream research consequences of the change.

Revision depth can vary. A local revision may alter one scope condition. A structural revision may change relations among several concepts. A categorical revision may divide or replace an analytical object. A mechanism revision may preserve observed regularities while changing their explanation. A deeper programme revision may reorganize which questions, models, or forms of evidence receive priority. Recording depth prevents a minor modification from being presented as a new theory and prevents a major conceptual change from being hidden behind unchanged terminology.

Theoretical accumulation can also contract. A claim once stated broadly can be narrowed after comparative evidence. A mechanism can be abandoned. A category can be retired. A model family can become a historical reference rather than an active analytical tool. Such contraction can increase programme quality by reducing unsupported generality. Chapter 3 already treated cumulative development as compatible with narrowing and abandonment; the present architecture supplies the records through which those changes remain traceable.

Revision should also preserve viable competing paths when evidence does not yet discriminate sufficiently. Premature convergence can make a programme appear coherent while reducing its capacity for later correction. Conversely, indefinite preservation of every alternative can make theoretical comparison unmanageable. The decision to maintain, merge, suspend, or retire a path should therefore be connected to evidential standing, conceptual usefulness, and the expected value of future discrimination.

Proposition 9.349 (Revision-sensitive theoretical cumulation). *Theoretical cumulation is strengthened when programme records preserve both continuity and transformation, allowing later researchers to distinguish retained commitments, qualified claims, abandoned structures, competing branches, and unresolved theoretical alternatives.*

This proposition prepares the more detailed treatment of theory in Section 260. A cumulative research programme supplies theory development with structured histories rather than an undifferentiated literature.

9.21.9 Intergenerational Research Memory

The longest horizon of cumulative research is intergenerational. Researchers inherit questions, categories, datasets, code, archives, model families, disputes, institutional routines, failures, and tacit expectations from people they may never meet. The quality of this inheritance shapes which earlier claims can be re-examined, which alternatives remain visible, and which apparent novelties are recognized as rediscoveries

of older problems. Intergenerational research memory is therefore a material and institutional condition of programme continuity.

Section 9.15 established preservation for historical re-epistemization, while Sections 9.17–9.20 developed governance, documentation, reproducibility, and reusability. Intergenerational memory coordinates those architectures over longer time spans. It asks whether future researchers can recover not only an artifact but also enough of its provenance, semantics, dependencies, disputes, and institutional context to determine what that artifact meant and what legitimate new uses remain available.

Definition 9.350 (Intergenerational programme memory). *Intergenerational programme memory* is the materially, institutionally, and semantically sustained capacity of later research communities to recover consequential research objects, their provenance and version histories, unresolved alternatives, conditions of access, and the reasons through which earlier projects altered programme knowledge.

Memory infrastructures can include repositories, code and model archives, data catalogues, bibliographic systems, community archives, shared vocabularies, research registries, institutional records, and maintained documentation. Knowledge-commons scholarship is useful here because shared epistemic resources require rules of access, contribution, stewardship, attribution, preservation, and legitimate restriction rather than mere release (Hess and Ostrom 2007). A programme that depends on cumulative resources therefore also depends on maintenance labor, institutional continuity, and governance arrangements capable of surviving personnel turnover.

Intergenerational memory should preserve heterogeneity. If repositories retain only standardized positive results, future researchers inherit a distorted research field. Negative results, superseded categories, failed models, abandoned hypotheses, unresolved disagreements, and context-rich materials can carry future epistemic option value. Their later significance cannot be predicted completely at the time of preservation. This provides a reason for selective diversity in archival strategy while remaining compatible with ethical, legal, security, privacy, and resource constraints.

Technological change complicates memory. File formats decay, computational environments disappear, identifiers break, platforms close, and AI-generated summaries can detach claims from their source contexts. Migration and abstraction can improve longevity while also losing detail. A durable programme therefore benefits from layered preservation: stable human-readable descriptions, machine-actionable metadata, version identifiers, preserved source artifacts where lawful, and explicit records of transformations introduced during migration.

Memory also has distributive dimensions. Which projects receive curation, which languages are indexed, whose data are preserved, who has access, and which forms of labor receive credit influence the future encounter surface of research. Cumulative architecture should therefore connect memory to the governance principles of Section 9.17. Preservation decisions participate in shaping what later researchers can know and which questions they can reasonably ask.

Proposition 9.351 (Intergenerational option preservation). *A cumulative research programme enlarges future epistemic option value when it preserves a sufficiently di-*

verse and provenance-rich memory of consequential findings, failures, alternatives, categories, and research objects under governance conditions that support legitimate later recovery and reinterpretation.

Proposition 9.351 does not make maximal retention a universal objective. Preservation competes with privacy, safety, consent, maintenance capacity, legal obligations, and the harms that some classifications or records can reproduce. The design problem is to preserve future epistemic possibilities proportionately while making deletion, restriction, or transformation decisions themselves reconstructible where appropriate.

The nine components of this section can be assembled into a programme-level cumulative record. For each consequential project contribution, the record can identify its programme relation, vocabulary versions, evidence relations, model-family position, comparative links, replication status, interpretation lineage, theory-revision consequences, preservation location, stewardship conditions, and unresolved questions. This record is best understood as a relational index across existing project artifacts rather than as a duplicative database containing every object again.

Such an index gives cumulative research a temporal structure. A later project can enter the programme by locating what it inherits, what it challenges, what it reuses, which dependencies it shares, and which branch of an unresolved problem it advances. The programme can then grow through refinement, differentiation, correction, and reopening as well as through extension. Cumulation becomes the organized capacity to make previous research productive for future inquiry while preserving enough history for that inheritance itself to remain contestable.

This architecture prepares Section 260, which turns from accumulation across projects to the development of theory within research praxis. The cumulative programme supplies theory development with shared concepts, differentiated evidence, model lineages, comparative results, replications, reinterpretations, and preserved alternatives; theory development determines how those materials reorganize the explanatory structures through which subsequent research is conducted.

9.22 Theory Development within Research Praxis

Section 9.21 described how multiple projects can become cumulative through shared vocabularies, evidence relations, model families, comparative records, replications, reinterpretations, revision histories, and intergenerational memory. The present section turns from the programme-level accumulation of research objects to the theoretical structures through which those objects are organized. Its role is to specify theory development as an explicit component of integrated research design. Its objective is to show how a project can generate theoretical outputs, recognize the theoretical conditions already shaping inquiry, compare alternatives, revise commitments, construct disciplined hybrids, replace theoretical architectures, contribute to the evolution of the GR research programme, and preserve competing theoretical paths when available warrant remains insufficient for closure. The method is recursive and version-sensitive: theory is treated simultaneously as something produced through research and as a condition that organizes later questions, categories, obser-

ventions, models, and judgments.

This reciprocal position has practical consequences. A theory can help identify an object before the project has produced evidence about that object. It can specify which relations deserve measurement, which cases count as comparable, which mechanisms appear plausible, and which anomalies are visible. Yet those same decisions can return as objects of criticism when field encounters, historical reconstruction, model–evidence dialogue, cross-method adjudication, or failed predictions reveal that the inherited theoretical structure is too coarse or mis-specified. Theory development therefore cannot be placed only at the beginning or the end of a research cycle. It operates through repeated movement among problem formation, representation, evidence, inference, comparison, and revision.

Chapter 6 already treated theory as a historically generated relational object whose concepts, propositions, scope conditions, representations, community relations, and evidential standing can change over time. The present task is more operational. Integrated research design needs a project-level architecture that records when theory is being used, when it is being tested, which part of it is implicated by a discrepancy, what kind of revision is proposed, which alternatives were considered, and how a newly adopted theoretical state differs from earlier states. Without such records, theoretical change can become retrospective narrative: later formulations appear inevitable, discarded alternatives disappear, and changes in concepts are mistaken for changes in the world itself.

Definition 9.352 (Theory-development architecture). A *theory-development architecture* is a project-level arrangement that records how theoretical concepts, propositions, explanatory relations, mechanisms, scope conditions, and representations enter inquiry, how they are confronted with evidence and alternatives, and how their retention, revision, hybridization, replacement, or preservation changes across research states.

Definition 9.352 does not require a project to begin with a fully articulated theory. Exploratory work can start from provisional concepts, weakly connected mechanisms, inherited disciplinary assumptions, or an open problem. The requirement is that consequential theoretical commitments become explicit enough to be criticized once they begin structuring the research process.

Table 9.13 summarizes the principal theory-development operations considered in this section.

9.22.1 Theory Formation through Inquiry

Theory can emerge as a research output when inquiry identifies a recurrent relation, mechanism, distinction, boundary condition, or explanatory structure that is not adequately represented by the project's initial framework. Such formation can occur through empirical regularities, historical reconstruction, interpretive comparison, formal analysis, simulation, intervention, or repeated failure of an inherited explanation. The theoretical output is therefore more than a summary of findings. It reorganizes findings into a structure that can orient further questions and expose itself to additional criticism.

Table 9.13: Project-level architecture for theory development within research praxis

Theoretical operation	Primary question	Required record	Characteristic failure
Formation	What theoretical structure is being produced from the inquiry?	Evidential trigger, inferred relation, scope, unresolved alternatives	Post hoc theorization without lineage
Conditioning	How is inherited theory shaping the inquiry?	Categories, salience, scales, method and comparison effects	Invisible theoretical loading
Comparison	Along which dimensions do theories overlap or differ?	Shared target, comparison criteria, translation loss, evidential standing	Single-metric ranking or false equivalence
Revision	Which commitment changes and why?	Trigger, retained elements, modified claims, downstream consequences	Repair without revision trace
Hybridization	What is transferred across theoretical lineages?	Source meaning, translated meaning, assumptions, residual incompatibilities	Seamless synthesis by terminological similarity
Replacement	Why does another architecture become preferable for the task?	Replacement trigger, preserved residues, changed scope, competing alternatives	Erasure of displaced theory
Programme evolution	How does a project alter the GR trajectory?	Branch relation, domain, version, new questions, constraints	Expansion by vocabulary alone
Path preservation	Which alternatives remain live, suspended, or retired?	Branch status, supporting evidence, unresolved tests, re-opening conditions	Premature convergence or indiscriminate retention

The route from evidence to theory is rarely one-step. A pattern can first appear as an observation, then become a tentative relation, then a mechanism claim, then a broader conceptual distinction. Each transition changes the inferential burden. A repeated association does not by itself establish a generative mechanism. A successful mechanism in one field does not automatically establish a general theoretical principle. A concept that clarifies several cases can remain heuristic until its scope and failure conditions are better understood. Integrated design should therefore preserve the sequence through which a theoretical object acquired stronger status.

Definition 9.353 (Theory-formation record). A *theory-formation record* documents the research pathway through which a candidate theoretical concept, proposition, mechanism, relation, or scope condition emerged, including its evidential triggers, inferential steps, alternative interpretations, current warrant, intended domain, and unresolved tests.

This record helps distinguish discovery from justification. A theoretical idea can arise through analogy, aesthetic judgment, an anomalous observation, AI-assisted generation, an interdisciplinary encounter, or a formal pattern before sufficient ev-

idence exists to warrant adoption. Such origins need not disqualify the idea. They clarify which later operations must provide support. Section 9.16 already required AI-proposed theory revisions to remain connected to an identifiable problem and verification pathway; the same discipline applies to human-generated theoretical novelty.

Theory formation can also be subtractive. Research may show that two concepts previously treated as separate are analytically redundant, that a presumed mechanism adds little explanatory value, or that a broad proposition should be decomposed into several narrower claims. Theoretical output therefore includes clarification, contraction, differentiation, and retirement as well as expansion.

Proposition 9.354 (Formation–warrant separation). *The route through which a theoretical candidate is generated should remain distinguishable from the evidential and inferential relations through which that candidate later acquires, loses, or changes warrant.*

Proposition 9.354 protects two forms of openness simultaneously. It permits unconventional sources of theoretical generation while preventing novelty, elegance, computational fluency, or narrative coherence from functioning as substitutes for support.

9.22.2 Theoretical Conditions of Inquiry

Theory also operates upstream of research output. It can define what counts as an object, supply categories, organize salience, suggest scales, identify expected relations, privilege particular forms of evidence, and shape the contrast classes through which cases are compared. Kuhn’s account of historically organized scientific practice remains relevant because inherited theoretical commitments can structure legitimate problems and expected forms of solution (Kuhn 1962). The project-level implication is narrower: consequential theoretical conditioning should be made inspectable where it affects design.

Theoretical conditioning can enter through explicit frameworks and through background assumptions. A project may openly adopt a theory of institutions while quietly assume stable actors, fixed category boundaries, or one-directional causation. A relational analysis can still inherit entity-centered measurement. A historical study can assume continuity in a category whose meaning changed. A formal model can encode theoretical commitments through boundary conditions or state variables even when the accompanying prose presents the model as neutral. These examples motivate a conditioning profile that reaches beyond named theoretical affiliations.

Definition 9.355 (Theoretical conditioning profile). *A theoretical conditioning profile identifies the consequential concepts, ontological commitments, category boundaries, scales, causal expectations, evidential priorities, and comparison structures through which a theoretical configuration shapes the design or interpretation of a research project.*

The profile should remain proportionate. Research need not document every intellectual influence. It should identify theoretical conditions whose alteration could materially change the question, object, representation, method, evidence interpreta-

tion, or claim. This connects directly to sensitivity analysis in Section 9.12: theoretical conditions can be treated as one source of design sensitivity when defensible alternative formulations exist.

Conditioning does not imply determination. The research architecture should preserve pathways through which evidence can resist the theory that helped make the evidence salient. Unexpected observations, participant disagreement, cross-method conflict, alternative models, historical discontinuity, and negative results can all reopen theoretical commitments. Longino's emphasis on organized critical interaction is useful here because theoretical responsiveness depends partly on whether alternative assumptions can effectively enter evaluation (Longino 1990).

Proposition 9.356 (Theory-conditioned openness). *When theoretical commitments materially shape the production or interpretation of evidence, integrated design should preserve practical routes through which observations, methods, or competing formulations can challenge those commitments rather than only instantiate them.*

The proposition links theoretical productivity with contestability. A theory can organize inquiry strongly while remaining revisable if the project preserves channels through which mismatches become diagnostically meaningful.

9.22.3 Theory Comparison

Theory comparison becomes necessary when several theoretical structures address overlapping phenomena, organize the same evidence differently, or imply different research directions. Comparison is most informative when the competing theories are first decomposed into comparable dimensions. Whole theories often differ simultaneously in categories, mechanisms, scales, temporal structure, scope, evidential requirements, explanatory aims, and normative commitments. A single ranking metric can therefore conceal why one theory appears stronger for one task and weaker for another.

A project can begin comparison by identifying the shared target. Two theories that use the same vocabulary may address different objects, while theories using different vocabularies may make competing claims about the same process. The next step is to specify comparison dimensions: empirical adequacy, historical adequacy, interpretive resolution, mechanism articulation, predictive performance, explanatory compression, representational tractability, scope, robustness, or capacity to generate discriminating research questions. The relevance of each dimension follows from the research purpose rather than from a universal hierarchy of theoretical virtues.

Definition 9.357 (Theory-comparison profile). *A theory-comparison profile is a structured account of two or more theoretical configurations that specifies their shared and non-shared targets, concepts, mechanisms, scales, scope conditions, evidential implications, comparison criteria, translation relations, and unresolved differences.*

Translation deserves explicit treatment. One theory's "capacity" may not correspond exactly to another theory's "resource." One account of power can describe a position in a relational field while another refers to a legally constituted authority. Apparent convergence may disappear once the terms are reconstructed. Conversely, competing terminology can hide a shared structural relation. The translation disci-

pline developed earlier in the book therefore applies to theory comparison as strongly as it applies to methods and categories.

Comparison can remain productive without immediate selection. Theories can be complementary when they operate at different scales or answer different questions. They can be competitive when they explain the same target through incompatible mechanisms. They can be partially overlapping when they share some claims while differing elsewhere. The project should preserve these configurations rather than forcing all plurality into one binary contest.

Proposition 9.358 (Function-sensitive theory comparison). *The warrant for preferring, combining, or retaining competing theories should be stated relative to explicit research functions and comparison dimensions, with translation loss and non-overlapping domains preserved where they materially affect the conclusion.*

This proposition prevents theory comparison from becoming an overall score. It also prepares the distinction among revision, hybridization, and replacement developed in the next three subsections.

9.22.4 Theory Revision

Theory revision occurs when a project changes theoretical commitments while preserving enough continuity that the new state remains recognizable as a development of the earlier one. Section 9.11 already distinguished parameter, structural, category, method, and theory revision within model–evidence dialogue. The present subsection generalizes that logic beyond formal models. A theory can be revised because of empirical discrepancies, failed translations, historical discontinuities, conceptual criticism, cross-method conflict, normative inconsistency, or the emergence of a new object that the current architecture cannot represent adequately.

Revision depth should be explicit. A local revision can narrow a scope condition. A mechanism revision can change the relation through which an observed pattern is explained. A categorical revision can split or reorganize the objects to which propositions apply. A structural revision can alter relations among several theoretical components. A deeper revision can reorganize which questions and evidential distinctions the project regards as central. These changes have different implications for continuity with earlier findings.

Definition 9.359 (Project theory-revision record). *A project theory-revision record documents a change in theoretical commitments by identifying the trigger, the earlier theoretical state, retained elements, altered concepts or relations, withdrawn or narrowed claims, affected evidence and models, competing revisions considered, and the consequences for subsequent research design.*

The record should distinguish revision from accommodation that merely protects a favored theory. The Duhem–Quine tradition cautions that adverse evidence can implicate a wider web of assumptions rather than uniquely identify one proposition for rejection (Duhem 1954; Quine 1951). This underdetermination makes diagnosis important. Yet diagnostic complexity should not become indefinite insulation. Repeated failure across reasonable auxiliary assumptions, representations, and methods can increase the case for revising a central theoretical relation.

Theory revision can also follow positive discovery. New evidence can reveal a distinction absent from the inherited framework even when no earlier prediction was directly contradicted. A new relation can connect previously separate domains. A formalization can expose ambiguity that ordinary prose allowed to remain hidden. A historical reconstruction can show that a category treated as stable was generated through changing institutions. In these cases revision enlarges theoretical resolution rather than repairing a falsified proposition.

Proposition 9.360 (Traceable theory revision). *A theory revision strengthens cumulative inquiry when later researchers can reconstruct what changed, which evidence or argument motivated the change, what remained invariant, and how the revised commitments alter the interpretation of earlier and later research objects.*

Version-sensitive revision therefore preserves the history of theoretical meaning. It prevents later terminology from being projected backward onto earlier research states.

9.22.5 Theory Hybridization

Hybridization constructs a theoretical configuration from elements originating in distinguishable lineages. It can be especially productive in GRE because relational, historical, interpretive, economic, legal, ecological, computational, and dynamical traditions can illuminate different dimensions of the same problem. Hybridization also carries a specific risk: theoretical elements that appear compatible at the level of vocabulary can depend on incompatible assumptions about objects, explanation, temporality, agency, or evidence.

A project should therefore treat hybridization as a translation problem before treating it as synthesis. For each imported element, the project can ask what role the element played in its source theory, which assumptions supported that role, what meaning changes under transfer, which inferential relations survive, and which residual incompatibilities remain. The objective is not to preserve source theories unchanged. It is to prevent the new configuration from claiming more continuity than the translation supports.

Definition 9.361 (Theory-hybridization record). *A theory-hybridization record documents the construction of a theoretical configuration from elements of distinct theoretical lineages by preserving the source role of each consequential element, its translated role, changes in meaning or assumptions, retained incompatibilities, evidential consequences, and the new claims enabled by the combination.*

Hybridization can occur at several levels. A project can combine concepts while retaining separate mechanisms. It can connect mechanisms through a shared process model. It can use one theory to define a domain and another to explain dynamics within that domain. It can place heterogeneous theories in a layered architecture without requiring ontological unification. These arrangements should be distinguished because they create different burdens of coherence.

Chapter 6 emphasized that GR draws selectively from heterogeneous traditions without treating them as interchangeable. That principle remains central here. Dynamical-systems language, field representations, historical interpretation, insti-

tutional analysis, capability concepts, or legal relations can enter GRE where they clarify the target, while their importation does not establish a hidden equivalence among the source traditions. Hybridization can preserve theoretical heterogeneity as an organized relation.

Proposition 9.362 (Hybridization with translation remainder). *Theory hybridization is epistemically stronger when consequential changes in meaning, assumptions, scope, and inferential role are recorded together with residual incompatibilities that the hybrid configuration does not resolve.*

The proposition makes theoretical remainder a research object. What cannot yet be translated can later motivate comparison, empirical discrimination, or further conceptual development.

9.22.6 Theory Replacement

Theory replacement becomes relevant when continued revision of an incumbent architecture produces less explanatory or investigative value than moving to a substantially different theoretical configuration. Replacement is stronger than revision because the project changes enough of its conceptual or explanatory grammar that earlier and later states can no longer be related mainly through local modifications. Even then, replacement need not imply that every component of the earlier theory loses value.

A replacement decision should identify its trigger. Repeated empirical failure is one possible trigger, but replacement can also follow persistent category mismatch, inability to represent a newly important relation, loss of coherence across accumulated revisions, or the availability of an alternative that explains the relevant evidence while opening stronger research possibilities. Popper's emphasis on criticism and exposure to possible refutation provides one precedent for maintaining theoretical vulnerability, while Kuhn's history of scientific change shows that large changes can also involve problem structures, standards, and conceptual organization (Popper 2002; Kuhn 1962). Integrated design need not adopt either account as a universal law of replacement.

Definition 9.363 (Theory-replacement decision). *A theory-replacement decision is a documented project judgment that another theoretical architecture provides materially stronger adequacy for the relevant research purpose than continued revision of the incumbent architecture, together with a record of replacement triggers, comparative grounds, retained residues, changed scope, and unresolved alternatives.*

Replacement should preserve useful residues. An earlier theory can contain a mechanism that remains locally adequate, a category useful for historical comparison, a dataset produced under its classifications, or an unresolved anomaly that motivated the transition. Section 9.15 showed why historical re-epistemization benefits from preserving earlier epistemic states; theory replacement is one case in which such preservation becomes especially important.

The project should also distinguish replacement from institutional displacement. A theory can lose visibility because a research community, funding regime, publication infrastructure, or methodological fashion changes. Such displacement can co-

incide with epistemic weakness, but the social fact of abandonment is not itself sufficient evidence that replacement was warranted. Conversely, a theory can retain institutional dominance after important parts of its warrant have weakened. Project records should therefore connect replacement to reasons rather than to popularity alone.

Proposition 9.364 (Replacement with theoretical residue preservation). *When a project replaces a theoretical architecture, cumulative value is increased by preserving the evidential reasons for replacement, the elements that remain locally useful, the relations that can still be translated, and the unresolved questions that the incoming theory has not settled.*

Replacement can therefore narrow one branch of inquiry while enlarging another. The programme-level consequences become the subject of the next subsection.

9.22.7 Evolution of the GR Research Programme

The preceding operations apply reflexively to GR. Generative Relational Theory and its domain-specific developments are intended to organize inquiry while remaining open to empirical, conceptual, historical, formal, and normative revision. A project using GR therefore has two possible theoretical relations to the programme. It can work within the current architecture, and it can generate evidence or concepts that alter that architecture. Integrated design should make the second possibility operational rather than merely declaring GR “revisable” in principle.

A project contribution to GR can take several forms. It can confirm the usefulness of an existing distinction under a new domain. It can narrow a concept whose current scope is too broad. It can show that two relations previously treated together should be separated. It can reveal that a formal representation captures only one manifestation regime. It can introduce a domain-specific concept that should remain local. It can identify a cross-domain invariance worthy of wider theoretical attention. It can also show that a GRE explanation adds little relative to an established theory for a specified problem. Each outcome changes the programme differently.

Definition 9.365 (GR programme-evolution record). *A GR programme-evolution record specifies how a research project changes the standing, scope, formulation, domain relation, or future research role of one or more GR concepts, mechanisms, representations, or programme commitments, including the evidential basis and version relation supporting that change.*

Programme evolution should preserve branching. Economics, law, education, ecology, political theory, aesthetics, neuroscience, and other domains can develop distinct relational representations because their objects, manifestations, methods, and normative problems differ. A shared GR vocabulary can support dialogue without requiring all domain branches to converge on one representation. Section 9.21 provided the cumulative infrastructure through which such branches can remain connected.

A generative criterion is also useful. Theoretical development is not strengthened merely because more phenomena can be restated with GR terminology. A programme change becomes more valuable when it improves the capacity to formulate

discriminating questions, expose hidden assumptions, connect previously separated evidence, identify mechanisms or boundaries, support responsible comparison, or reveal where the programme itself should contract. This criterion preserves the difference between conceptual expansion and research progress.

Proposition 9.366 (Reflexive programme evolution). *A GR research project contributes to programme evolution when its findings or theoretical work produce a reconstructable change in the scope, meaning, evidential standing, relation, or research function of GR elements while subjecting those elements to the same criticism and uncertainty architecture applied to competing theories.*

This reflexive requirement is especially important under AI-assisted theoretical abundance. Candidate extensions can be generated rapidly; the scarce operation becomes disciplined discrimination among them. The programme should therefore value preserved reasons for adoption, rejection, narrowing, and suspension as much as the volume of theoretical production.

9.22.8 Preservation of Competing Theoretical Paths

Theory development rarely produces a single uncontested path at every stage. Competing branches can remain because evidence is underdetermining, because theories answer different questions, because translations remain incomplete, because a decisive test is unavailable, or because one branch performs better at one scale while another performs better elsewhere. Integrated research design should distinguish unresolved plurality from indecision and preserve alternatives in proportion to their remaining epistemic relevance.

Preservation requires status distinctions. A theoretical path can be active, conditionally retained, suspended pending evidence, historically preserved, or retired for the present domain. These statuses should not be inferred from whether a path appears in the final narrative. A branch omitted from the main analysis can remain important if it identifies a plausible alternative mechanism or a boundary condition that later evidence could reopen.

Definition 9.367 (Theoretical branch archive). *A theoretical branch archive is a versioned record of competing or superseded theoretical paths that preserves their core commitments, evidential supports and challenges, relation to the adopted path, current status, unresolved discriminating questions, and conditions under which future inquiry could reopen them.*

Preservation should remain selective. Retaining every speculative possibility can make theory comparison unmanageable and obscure alternatives with substantial evidential support. The project should therefore record why a branch remains live. Reasons can include empirical adequacy, explanatory complementarity, unresolved translation, underpowered discrimination, historical importance, or future option value. A branch with repeated decisive failures and no remaining research function can be retired while its revision history remains available.

Theoretical plurality also has an ethical and institutional dimension. Dominant research infrastructures can make some theoretical paths easier to operationalize, publish, fund, or teach. Such asymmetries do not establish the correctness of marginal-

ized alternatives, yet they can influence which alternatives receive sufficient development to become testable. The governance architecture of Section 9.17 therefore matters for theory development as well as for data and authorship.

Proposition 9.368 (Preservation of discriminating theoretical options). *Competing theoretical paths should remain reconstructable when available evidence or translation does not yet justify their exclusion and when preserving them retains meaningful future capacity for discrimination, reinterpretation, or domain-specific use.*

The eight operations developed in this section can be joined into a project-level theory-development record. For each consequential theoretical state, the project can identify its formation pathway, inherited conditioning role, comparison set, revisions, hybrid sources, replacement relations, GR programme consequences, and surviving alternatives. This record need not duplicate the full theoretical argument. Its purpose is to make the trajectory of theoretical commitment reconstructible across the research cycle.

Theory development then becomes part of research praxis rather than a separate philosophical layer placed above empirical work. Theory helps constitute the conditions of inquiry, inquiry generates pressures and possibilities for theory, and cumulative research preserves the history through which those relations change. The next section turns from theoretical development to another class of consequential operations within research-dominant praxis: the decisions through which researchers allocate attention, choose among alternatives, close or reopen analytical paths, and act under incomplete epistemic conditions while still pursuing research rather than application as the dominant practical orientation.

9.23 Research Decisions within Research-Dominant Praxis

The preceding sections have progressively specified the architecture of an integrated research project: questions, cases, fields, data, representations, methods, models, sensitivity, robustness, uncertainty, historical preservation, AI-assisted workflow, governance, documentation, reproducibility, reusability, cumulative research, and theory development. The present section turns to the decisions that connect these components through time. Its role is to make explicit that research-dominant praxis is already practical activity. Inquiry allocates attention, excludes alternatives, commits resources, contacts participants, transforms data, adopts models, publishes classifications, and sometimes intervenes in the world in order to learn. Its objective is to specify how such decisions can remain oriented primarily toward epistemic development while still acknowledging normative inputs, incomplete knowledge, and the risks generated by research action. The section proceeds through decisions about questions, evidence, methods, models, intervention, incomplete knowledge, normative inputs, research-action risk, and the transition of the principal contradiction.

The distinction between research-dominant and application-dominant praxis therefore cannot be drawn by asking whether a project contains decisions or actions. Both do. The more useful distinction concerns what currently organizes the praxis configuration. In research-dominant praxis, consequential choices are principally ordered toward producing, criticizing, or revising warranted knowledge. In

application-dominant praxis, the organizing pressure increasingly concerns what should be done in a practical field under finite time, responsibility, and incomplete knowledge. The same project can move between these orientations, and the same operation can change function across phases.

This functional distinction matters because research decisions can have practical consequences long before a project is described as an intervention. Choosing a category can affect recognition. Selecting a sample can determine whose experience becomes visible. Releasing a dataset can alter privacy or institutional power. Publishing a prediction can influence behavior. A field experiment can reorganize relations among participants. Even non-intervention can preserve an existing exposure or allow a time-sensitive opportunity to disappear. Research-dominant orientation therefore reduces neither responsibility nor the need for explicit decision architecture.

Definition 9.369 (Research-decision architecture). A *research-decision architecture* is a project-level arrangement that identifies consequential choices within research-dominant praxis, specifies their epistemic purpose and practical effects, records the alternatives and uncertainties relevant to them, allocates decision authority and review, and defines conditions for revision, escalation, or transition to application-dominant praxis.

Definition 9.369 treats decision making as part of research design rather than an invisible background activity. The architecture need not formalize every routine choice. Its purpose is to preserve traceability for decisions that can materially alter the research question, evidence base, inferential pathway, affected relations, or future option space.

Table 9.14 summarizes the principal decision domains developed in this section.

9.23.1 Decisions about Questions

A research question is produced through judgment rather than discovered as a neutral sentence already contained in reality. Section 9.2 showed that descriptive, relational, historical, interpretive, causal, generative, and normative questions impose different inferential requirements. A project must therefore decide which uncertainty is sufficiently consequential to organize inquiry, which dimensions can be bracketed provisionally, which populations or relations enter the boundary, and how the question will remain open to transformation when evidence makes the initial formulation inadequate.

Question choice allocates scarce epistemic capacity. Time spent investigating one relation is time unavailable for another. The chosen wording also distributes visibility. A question centered on average outcomes can obscure heterogeneous trajectories; a question centered on individual characteristics can background institutions; a question centered on present conditions can suppress historical formation. These effects do not make question selection illegitimate. They make its selectivity part of the research record.

Definition 9.370 (Question-decision record). A *question-decision record* documents the salience judgment, intended epistemic contribution, principal alternatives consid-

Table 9.14: Decision domains within research-dominant praxis

Decision main	do-	Primary function	research	Required discipline	Characteristic failure
Questions		Allocate inquiry toward a tractable and consequential problem		Salience, scope, alternatives, revision triggers	Premature question closure
Evidence		Determine what can bear on a claim		Relevance, provenance, exclusion record, stopping conditions	Evidence selected to stabilize a preferred conclusion
Methods		Choose epistemic access and inferential procedure		Question–method fit, complementarity, blind spots	Method availability treated as methodological adequacy
Models		Select and use representations for specified functions		Role, assumptions, sensitivity, alternatives, revision depth	Model convenience converted into ontological commitment
Intervention		Generate knowledge through purposive alteration where warranted		Epistemic necessity, exposure, monitoring, reversibility, exit	Practical transformation hidden behind research language
Incomplete knowledge		Decide while relevant uncertainty remains		Decision threshold, uncertainty profile, option preservation	Either paralysis or unjustified closure
Normative inputs		Govern values entering design and judgment		Visibility, source, contestability, separation from empirical warrant	Normative premises presented as empirical findings
Research-action risk		Anticipate harms and option loss generated by inquiry		Affected relations, distribution, persistence, mitigation, repair	Risk confined to participants or immediate study period
Praxis transition		Detect when practical closure becomes organizing		Principal-contradiction reassessment and governance escalation	Application decisions continuing under research-only safeguards

ered, boundary and scale assumptions, feasibility constraints, normative relevance, and conditions under which a research question should be narrowed, expanded, decomposed, or replaced.

The record should preserve the difference between a question being important and a question being researchable in its present form. Some questions carry substantial practical or normative significance while exceeding the available evidential access. Others are technically tractable yet make only a limited contribution to the underlying problem. Research-dominant praxis often requires a sequence of questions whose combined role is stronger than any single formulation.

Question decisions are therefore provisional commitments. They stabilize inquiry long enough to coordinate evidence and method while retaining a path for re-questioning. The transformation logic established in Section 9.2 becomes a decision rule here: new evidence can reveal that the original question conflated categories, missed a relevant relation, assumed an inappropriate scale, or required a different

claim type.

Proposition 9.371 (Question commitment with reopening conditions). *A consequential research question is better governed when the project records both the reasons for committing to it and the conditions under which evidence, ethical change, boundary failure, or theoretical revision would justify reopening the question itself.*

Proposition 9.371 protects research from two opposite errors. Continual reformulation can prevent cumulative inquiry, while rigid adherence can force new evidence into an obsolete problem structure. Integrated design requires enough stability for work to proceed and enough permeability for the object to transform the inquiry.

9.23.2 Decisions about Evidence

Evidence decisions determine what material is acquired, retained, excluded, prioritized, linked, and judged sufficient for a specified claim. Section 9.6 developed data architecture, while Sections 9.10–9.14 addressed adjudication, model–evidence dialogue, sensitivity, robustness, and uncertainty. The decision problem is how to act within those architectures when evidence remains finite, uneven, costly, ethically constrained, or potentially endless.

Relevance is claim-dependent. A source can be highly informative for reconstructing institutional meaning and weak for estimating prevalence. A large dataset can support precise measurement of a narrow manifestation while remaining poor evidence for an unobserved mechanism. A historical archive can reveal sequence and category change while reflecting systematic preservation bias. Evidence decisions should therefore be justified by the inferential role assigned to material rather than by volume, novelty, accessibility, or prestige alone.

The project must also decide when evidence collection should stop. Absolute evidential completeness is generally unavailable. Additional collection can improve identification, expose heterogeneity, or resolve contradictions, but it can also consume resources without materially changing the warranted claim. Stopping should therefore be tied to a specified epistemic purpose, remaining uncertainty, expected information gain, ethical burden, resource constraints, and the consequences of premature closure.

Definition 9.372 (Evidence-decision profile). *An evidence-decision profile records which evidential materials are sought, admitted, excluded, prioritized, or left uncollected for a specified claim; the inferential role of each class; material access and ethical constraints; relevant dependencies; and the conditions under which additional evidence would be expected to change the project judgment.*

Exclusion deserves particular visibility. Material can be excluded because it is outside scope, methodologically weak, duplicative, inaccessible, ethically inappropriate to use, legally restricted, temporally mismatched, or incompatible with a category regime. These are different reasons. A project that records only included evidence can make later readers unable to distinguish principled exclusion from convenience or selection toward a preferred conclusion.

Proposition 9.373 (Evidence selection with inferential traceability). *Evidence selection supports stronger research warrant when inclusion, exclusion, prioritization, and*

stopping decisions remain traceable to the claim, inferential function, uncertainty architecture, and relevant ethical or access constraints.

This proposition also constrains evidential abundance. Generating more observations, retrievals, simulations, or AI-produced summaries does not by itself improve a claim if the new material repeats the same dependency structure or fails to address the uncertainty driving the decision.

9.23.3 Decisions about Methods

Method decisions allocate epistemic access. Sections 9.8–9.10 established the method portfolio, sequencing, and cross-method adjudication of an integrated project. The decision problem is therefore broader than selecting a familiar technique. The project must decide which dimensions of the target require which forms of access, which method should carry the principal inferential burden, which supporting methods can expose blind spots, and when a method should be abandoned or supplemented.

Availability exerts strong pressure on method choice. Researchers may possess a dataset, software package, experimental platform, archival collection, or disciplinary skill before the question has been fully specified. Such resources can legitimately shape feasibility, but they should not silently reverse the direction of design by making the available technique determine the claim that will be pursued. A method can be excellent for one inferential task and structurally incapable of resolving another.

Definition 9.374 (Method-decision record). *A method-decision record specifies the research function assigned to a method, the question and representation to which it is linked, the alternatives considered, known blind spots and assumptions, sequencing relations, expected complementary evidence, and criteria for modification, supplementation, or withdrawal.*

Method decisions also affect people and institutions. An interview can demand disclosure; a sensor can intensify observation; a randomized intervention can distribute exposure; automated classification can impose categories; archival work can reproduce restrictions or reveal sensitive histories. Methodological adequacy and ethical acceptability therefore remain related but non-identical judgments.

Pluralism does not eliminate choice. A project rarely has resources to use every method that could illuminate the target. Integrated design requires selective plurality: enough differentiation to test important dependencies and reveal consequential blind spots, without multiplying methods beyond the project's capacity to execute, interpret, and govern them well.

Proposition 9.375 (Method choice by epistemic function). *Method selection is better justified when the project can state which epistemic function requires the method, which relevant dimensions remain outside its access, and why the resulting portfolio provides adequate rather than merely abundant methodological coverage.*

9.23.4 Decisions about Models

Model decisions concern whether to formalize, which representation to adopt, how much structure to impose, which parameters or categories to estimate, and what evidential or practical function the resulting model will perform. Section 9.11 estab-

lished that model–evidence conflict can require revision at several depths, while Sections 9.12 and 9.13 separated sensitivity from robustness. The present task is to identify the decision points through which models enter and leave a research project.

A model can support reconstruction, explanation, comparison, mechanism articulation, prediction, counterfactual exploration, simulation, or theory criticism. These functions impose different adequacy requirements. A model useful for clarifying a mechanism can be too stylized for prediction. A predictive model can perform well while leaving causal structure opaque. A historical model can organize sequence without supporting transport to a different institutional regime. Decisions about models should therefore begin with function rather than with mathematical sophistication.

Definition 9.376 (Model-use decision). A *model-use decision* is a documented judgment to introduce, retain, revise, compare, restrict, or withdraw a model for a specified research function, together with the model’s assumptions, target relation, evidential basis, sensitivity and robustness profile, relevant alternatives, and conditions under which its current use should be reconsidered.

Model convenience can create path dependence. Once a representation has generated code, figures, parameter estimates, team expertise, and publication plans, replacing it becomes costly. These sunk investments can make a model appear more indispensable than its evidential warrant supports. The governance and documentation architectures developed in Sections 9.17 and 9.18 therefore apply to model retention as well as to model creation.

A decision to avoid formalization can also require justification. Some targets are under-specified, meaning-laden, historically singular, or evidentially sparse in ways that make premature formalization more distorting than clarifying. Formal restraint can preserve distinctions until they become sufficiently understood for a model to perform a useful analytical function.

Proposition 9.377 (Function-bounded model commitment). *Commitment to a model should remain bounded by the research function and evidential conditions for which its adequacy has been examined, while extension to a new function, scale, population, or decision context requires renewed assessment.*

This proposition prepares the next section, which will examine how formal and empirical models change function across research-dominant and application-dominant praxis.

9.23.5 Decisions about Intervention

Research-dominant praxis can include intervention when purposive alteration of a field is used principally to generate or discriminate knowledge. Experiments, elicitation procedures, pilot systems, participatory workshops, archival digitization, measurement infrastructures, and field manipulations can all alter the relations through which evidence becomes available. The existence of intervention therefore does not by itself make a project application-dominant. The relevant question is what function the intervention performs and what practical consequences accompany it.

Definition 9.378 (Research-directed intervention). A *research-directed intervention*

is a purposive alteration of a research field, relation, information environment, or experimental condition whose primary project function is epistemic, while its practical effects on participants, institutions, environments, or future options remain subject to explicit ethical and governance assessment.

The definition prevents an epistemic purpose from neutralizing practical consequences. A field experiment can redistribute opportunity. A survey can make a sensitive category salient. A pilot algorithm can influence staff judgment even when introduced for evaluation. A public dashboard can change organizational behavior. An experimental platform can create dependencies that continue after the study. Research-directed intervention therefore requires attention to exposure, persistence, reversibility, affected-party knowledge, monitoring, and exit.

The decision to intervene should also be compared with less transformative routes to the same epistemic objective. Observational, historical, natural-experimental, simulation, or comparative approaches can sometimes answer the question with lower exposure or greater reversibility. In other cases, intervention is the only credible route for discriminating mechanisms or learning about implementation. The comparison should concern epistemic gain and practical consequence together rather than treating intervention as either presumptively superior or presumptively impermissible.

Definition 9.379 (Research-intervention decision profile). *A research-intervention decision profile records the epistemic necessity and expected information gain of a proposed intervention, plausible non-interventional alternatives, affected relations, exposure distribution, reversibility, monitoring, stopping conditions, repair capacity, and pathways for incorporating intervention-generated evidence into later inquiry.*

Proposition 9.380 (Epistemic purpose with practical consequence). *An intervention can remain part of research-dominant praxis when its organizing function is epistemic, but its practical consequences should be governed according to their actual scope and severity rather than discounted because the intervention is conducted for research.*

This distinction becomes increasingly important as research infrastructures become capable of influencing large populations or institutional processes. Scale can move an activity toward application-dominant conditions even when its originating intent remains investigative.

9.23.6 Decisions under Incomplete Knowledge

Every preceding decision is made before the project possesses complete knowledge of its target or of the consequences of its own choices. Section 9.14 organized uncertainty into several layers, and Section 9.13 clarified that robustness does not eliminate uncertainty. Research-dominant praxis therefore requires a decision discipline that can act provisionally without converting incompleteness into either indefinite paralysis or unwarranted certainty.

The relevant threshold depends on the decision. Choosing a provisional coding scheme can tolerate more uncertainty than releasing identifiable data. Trying an alternative model can require less prior justification than exposing participants to an irreversible intervention. Publishing an exploratory claim can be appropriate under

uncertainty if its status is clearly marked, whereas using the same claim to determine consequential treatment can demand a substantially stronger basis. A single universal evidence threshold would therefore conceal the relation between uncertainty and consequence.

Definition 9.381 (Research decision threshold). *A research decision threshold is the project-specific level and configuration of evidential support, uncertainty, reversibility, consequence, and option preservation judged sufficient for a specified research action to proceed while remaining open to revision.*

Thresholds should be explicit enough to be criticized. They need not always be numerical. A qualitative threshold can specify that two independent evidential pathways are required before a claim changes status, that a sensitive dataset will not be released while re-identification risk remains materially unresolved, or that an intervention will be paused when a specified adverse pattern appears. The important feature is the relation between the threshold and the decision it governs.

Option preservation becomes especially valuable under deep uncertainty. A reversible pilot, staged data release, modular model architecture, parallel theory branch, or delayed commitment can permit learning while keeping future alternatives available. Such strategies have costs and can themselves create path dependence, but they reduce the need to make every uncertain choice globally binding.

Proposition 9.382 (Consequence-sensitive provisional closure). *When research must proceed under incomplete knowledge, the burden of prior support and the value of reversibility, monitoring, and option preservation should be assessed relative to the plausible consequences of the specific decision rather than inferred from a single project-wide standard of certainty.*

Provisional closure is therefore an epistemic achievement when it states what is sufficiently settled for the present operation, what remains uncertain, and what observations would reopen the decision.

9.23.7 Normative Inputs

Research decisions are not generated by evidence alone. Judgments about importance, acceptable burden, privacy, fairness, participation, preservation, openness, risk tolerance, affected interests, and responsible dissemination contain normative inputs. Even apparently technical decisions can depend on values when they determine whose error matters, which uncertainty deserves attention, or which tradeoff is acceptable. Integrated design should therefore make normativity inspectable without converting empirical claims into expressions of preference.

Normative inputs can enter at several points. They can influence problem salience, participant inclusion, protection standards, evidence thresholds, model loss functions, disclosure rules, interpretation of practical significance, and the decision to continue or stop an intervention. Their sources can include professional norms, law, institutional policy, community expectations, participant commitments, disciplinary standards, ethical reasoning, and the researchers' own judgments. These sources can converge or conflict.

Definition 9.383 (Normative-input record). A *normative-input record* identifies a value-laden premise materially affecting a research decision, the decision domain in which it operates, its source and justification, actors affected by it, plausible alternatives, relevant conflicts, and the pathway through which it can be contested or revised.

Explicit normativity does not require reducing every methodological choice to ethics. Some decisions are primarily technical, and some empirical findings remain independent of whether they are desirable. The design task is to identify where normative premises materially enter the decision relation and to prevent them from being smuggled into claims as if they were empirical results.

Normative disagreement can remain unresolved while research proceeds. A project can sometimes preserve multiple value configurations and examine how conclusions change under them, much as Section 9.12 treated normative sensitivity. In other cases, governance requires a practical normative commitment before the research can continue, such as a privacy threshold or consent condition. The distinction should be documented rather than obscured.

Proposition 9.384 (Visibility of normative decision premises). *When a normative premise materially changes a research decision, evidential threshold, representation, or distribution of research consequences, making that premise explicit improves the contestability of the decision without converting the premise into an empirical finding.*

Normative visibility also supports later reinterpretation. Future researchers can distinguish a conclusion that changed because new evidence appeared from one that changed because the accepted value configuration or institutional obligation changed.

9.23.8 Risk of Research Action

Research action can generate risk through more pathways than direct physical or psychological exposure during data collection. It can alter visibility, classification, reputation, privacy, institutional response, resource allocation, bargaining position, technological dependence, ecological conditions, and future research possibilities. Risk can also be distributed unevenly: researchers may receive information and professional benefit while participants or affected communities bear disclosure, stigma, surveillance, or downstream reuse consequences.

A generative perspective broadens the temporal horizon. Publication can outlive consent expectations. A category introduced for analysis can later become administrative. Open data can enable beneficial reuse and unforeseen re-identification. A model released for research can become embedded in decision systems. A study that changes organizational expectations can alter the baseline for later inquiry. Risk assessment should therefore include plausible pathways through which research actions modify later relations and options.

Definition 9.385 (Research-action risk profile). A *research-action risk profile* specifies plausible adverse changes generated through a research decision or activity, the actors and relations exposed, distribution and persistence of consequences, relevant uncertainty, reversibility and repair capacity, monitoring signals, mitigation measures,

and conditions for suspension or redesign.

The profile should preserve the possibility of benefit without treating expected benefit as automatic compensation for imposed risk. Research can expand recognition, build capacities, preserve threatened materials, reveal hidden harms, improve methods, or create public knowledge infrastructures. These generative benefits are analytically important. Their existence does not remove the need to identify who bears risk, who receives benefit, and who has authority to make the tradeoff.

Risk can also arise from inaction. Refusing to collect time-sensitive evidence can allow a historical record to disappear. Delaying disclosure of a serious measurement failure can allow misleading findings to propagate. Avoiding a difficult population can reproduce evidence gaps. The relevant comparison is therefore among feasible research actions and non-actions rather than between action and an imagined zero-risk baseline.

Proposition 9.386 (Relational and temporal assessment of research risk). *Research-action risk is better assessed when the project compares plausible action and non-action pathways across affected relations, distributions, temporal horizons, reversibility, and downstream reuse rather than restricting assessment to immediate study procedures.*

This broader profile connects research ethics with cumulative research design. The same documentation that supports reproducibility and reuse can also reveal when later uses move beyond the risk conditions under which an object was originally created.

9.23.9 Transition of the Principal Contradiction

The distinction between research-dominant and application-dominant praxis becomes most useful at the point of transition. Chapter 6 defined the principal contradiction of research-dominant praxis around the need to stabilize an epistemic-theoretical system while relational reality remains partially known and capable of exceeding those stabilizations. Application-dominant praxis is organized more strongly by the need to act under incomplete knowledge in a field that can be transformed by the action itself. Section 9.23 has shown that both contradictions can already be present within research. The project-level question is when their relative organizing significance changes.

Transition can occur gradually. A research model may begin as an explanatory instrument, later inform scenario comparison, then become embedded in resource allocation. A pilot may begin as a limited experiment, become operationally useful, and persist beyond the study. A category developed for analysis may become an administrative classification. A research team may be asked to make recommendations before evidential uncertainty has been resolved. In each case, the original epistemic purpose can remain present while practical closure begins to organize attention, timing, responsibility, and acceptable error more strongly.

Definition 9.387 (Praxis-mode transition signal). *A praxis-mode transition signal is a material change indicating that practical decisions about allocation, treatment, authorization, exposure, institutional action, or consequential non-action are becoming sufficiently organizing that the project's principal contradiction, governance require-*

ments, or standards of adequacy should be reassessed.

Useful signals can include increased consequence of model error, external dependence on research outputs, reduced reversibility, urgency that compresses evidential timelines, expansion in affected populations, transfer of authority to operational actors, persistent intervention beyond an experimental window, or a shift from learning about options to choosing among them for practical implementation. No single signal is universally decisive. Their significance depends on the configuration.

A change of praxis mode should trigger more than a change of label. Evidence that was adequate for exploration may be insufficient for high-stakes decision support. A model that was acceptable because its errors were epistemically informative may require stronger calibration, contestability, and monitoring when its outputs affect access or treatment. An intervention governed as a research procedure may require operational accountability, repair capacity, and longer-term evaluation when it becomes part of institutional practice.

Definition 9.388 (Principal-contradiction reassessment). *A principal-contradiction reassessment is a documented review of which contradiction currently most strongly organizes attention, judgment, resources, action, and revision within a project phase, together with the implications of that change for evidence thresholds, model function, ethical review, governance, monitoring, and closure.*

Proposition 9.389 (Transition by organizing function). *A project should treat movement toward application-dominant praxis as a change in the organizing function of its decisions and consequences, rather than infer the transition solely from institutional setting, researcher intention, or the presence of an intervention.*

This proposition preserves continuity without collapsing the two praxis modes. Research can remain research-dominant while containing decisions, normative commitments, and carefully governed intervention. Application can remain strongly research-coupled while requiring practical closure before uncertainty is fully resolved. The distinction becomes analytically useful when it identifies which contradiction is currently organizing the project and which safeguards follow from that organization.

The section can therefore be summarized through a decision record that travels with the project. For each consequential choice, the project can record the decision object, epistemic purpose, alternatives, evidence and uncertainty, normative inputs, affected relations, risk and reversibility, responsible authority, reopening conditions, and any transition signal. Such a record joins the governance and documentation architectures already developed without duplicating them: governance identifies who can decide and review; documentation preserves what occurred; the decision architecture specifies why a consequential path was chosen under the conditions then available.

Research-dominant praxis is thus neither action-free nor normatively empty. Its distinctive orientation lies in practical choices principally organized around producing and revising warranted knowledge. The next section examines formal and empirical models as boundary objects whose functions can shift across praxis modes.

9.24 Uses of Formal and Empirical Models across Praxis Modes

The preceding section developed the decisions through which research-dominant praxis selects questions, evidence, methods, models, and research-directed interventions under incomplete knowledge. The role of the present section is to examine one object that can travel across those decisions while changing its practical significance: the formal or empirical model. Its objective is to distinguish the principal functions that models can perform across research-dominant and application-dominant praxis, and to specify how evidential burden, uncertainty, governance, and responsibility change when model function changes. The discussion proceeds from epistemic reconstruction, explanation, prediction, and counterfactual exploration through theory critique, generation, and transformation, then turns to decision support, scenario comparison, intervention design, risk assessment, and learning through action. The final subsection integrates these uses through a model-function transition architecture. The method is comparative and project-architectural: model form, model function, evidential support, and practical consequence are treated as distinct but connected components of research design.

Formal and empirical models enter Generative Relational research in heterogeneous forms. A formal model can encode relations, state spaces, transition rules, partial orders, symmetries, network structures, stochastic processes, constraints, or generative mechanisms. An empirical model can estimate associations, distributions, effects, latent structures, predictive relations, or measurement mappings from observed material. Many research objects combine both characteristics. A calibrated dynamical system, estimated network model, empirically parameterized simulation, or statistically estimated causal representation contains formal structure together with empirical commitments. The important project-level question is therefore less whether a model is formally or empirically oriented than what inferential and practical work the model is being asked to perform.

Model function can change while mathematical form remains stable. An estimated model can first summarize historical patterns, later support an explanatory argument, then be used to compare scenarios or guide allocation. A simulation can begin as a theory-generating device and later become part of intervention design. A relational map can serve as a reconstructive representation before becoming an operational tool for identifying points of intervention. These transitions alter the consequences of model error. A representation that is useful for exploratory inquiry can remain appropriate despite wide uncertainty because its purpose is to expose possibilities or contradictions. The same uncertainty can become materially consequential when outputs influence treatment, eligibility, infrastructure, or resource distribution.

Definition 9.390 (Praxis-indexed model use). A *praxis-indexed model use* is a documented specification of a model's current function, target object, evidential basis, inferential claim, uncertainty profile, affected decisions, governance conditions, and revision requirements within a particular phase of research-dominant or application-dominant praxis.

Table 9.15: Model functions across research and application praxis

Model function	Primary project role	Characteristic model claim	Additional discipline for consequential use
Epistemic reconstruction	Organize incomplete manifestations into an explicit representation	A specified reconstruction is compatible with and useful for the available record	Provenance, alternative reconstructions, representation loss
Explanation	Articulate relations, mechanisms, conditions, or generative organization	The represented structure contributes to understanding the observed process	Mechanism evidence, scope, competing explanations
Prediction	Estimate future or unobserved states under stated conditions	The model has predictive adequacy within a defined horizon and regime	Calibration, transport, drift monitoring, error distribution
Counterfactual exploration	Compare modeled trajectories under altered conditions	Specified alternatives generate different represented consequences	Assumption visibility, counterfactual identification, plausibility
Theory critique	Expose inconsistency, omission, non-identifiability, or failed implication	A theoretical commitment encounters a disciplined formal or empirical challenge	Diagnostic localization, alternative assumptions, revision path
Theory generation and transformation	Produce or reorganize candidate theoretical structures	Model behavior suggests new concepts, mechanisms, or relations for inquiry	Separation of generation from warrant, independent confrontation
Decision and scenario support	Inform practical comparison without uniquely determining choice	Modeled consequences are relevant inputs to a decision under stated conditions	Value visibility, contestability, decision threshold, uncertainty communication
Intervention and risk design	Represent actions, pathways, side effects, and failure conditions	A specified intervention or risk pathway is plausible within the modeled field	Feasibility, reversibility, distribution, monitoring, accountability
Learning through action	Update models through observed consequences of intervention	Action generates evidence that can revise the model and the intervention	Feedback governance, stopping rules, ethical review, versioning

Definition 9.390 separates the model from its use. A model does not possess one fixed epistemic status independent of the role assigned to it. The same formal object can support several uses, but the warrant for one use does not automatically transfer to another. A model that reconstructs an observed trajectory adequately can still have weak predictive transport. A model that predicts well can remain limited as an explanation. A model that is useful for scenario comparison can remain insufficient for intervention design when the mapping from modeled controls to feasible actions is uncertain.

Table 9.15 summarizes the principal model functions developed in this section. The final column identifies the additional discipline that becomes increasingly important as a model moves closer to practical action. The ordering is analytical rather than a mandatory sequence; projects can enter the architecture at different points and can move backward when evidence or consequences require revision.

The table also clarifies the relation between Sections 9.11 and 9.23. Model–evidence dialogue determines how representations change when confronted with evidence. Research–decision architecture determines why a consequential model use is selected under available knowledge. The present section connects these two architectures by asking how the standards applied to a model should change when its function changes.

9.24.1 Epistemic Reconstruction

Epistemic reconstruction is the use of a model to organize incomplete manifestations into an explicit representation of a target relation, event sequence, field, mechanism, or trajectory. Its role is especially important when the relevant object is not directly observable as a complete empirical unit. The objective is to make inferential bridges visible: which observations anchor the reconstruction, which relations are inferred, which gaps are interpolated, which categories are imposed, and which alternatives remain admissible. The method can be formal, empirical, historical-computational, or mixed, provided that the reconstruction remains distinguishable from the manifestations through which it was inferred.

A reconstructive model can organize fragmented evidence without claiming that the reconstructed object has been observed directly. A temporal model can infer missing states between documented events. A relational model can estimate hidden ties from patterned manifestations. A latent-variable model can represent an unobserved construct through measured indicators. A historical simulation can test whether a proposed sequence is dynamically coherent under specified constraints. The epistemic value lies in rendering an otherwise dispersed inference inspectable and contestable.

Reconstruction is therefore compatible with plurality. Several model architectures can fit the same manifestations while preserving different distinctions. The project should retain alternative reconstructions when the evidence does not discriminate sufficiently among them. Section 9.10 developed the broader adjudication principle; reconstructive modeling applies it to representations of the target object itself.

Definition 9.391 (Reconstructive model profile). A *reconstructive model profile* records the target object, observed anchors, inferred components, representation choices, boundary and scale, alternative admissible reconstructions, uncertainty, and evidence that could discriminate among them.

A reconstructive model can later support explanation or prediction, but that transition requires additional warrant. Compatibility with the observed record establishes that a reconstruction is admissible within the specified architecture. It does not by itself establish that the represented relations generated the record, that they will persist, or that manipulating one represented component will produce a corresponding empirical change.

Proposition 9.392 (Reconstruction-specific warrant). *Warrant for epistemic reconstruction should be attached to correspondence between the represented structure and the available evidential record, together with explicit treatment of inferential gaps and admissible alternatives; stronger explanatory, predictive, or intervention claims require additional support specific to those functions.*

9.24.2 Explanation

Explanatory model use organizes evidence around relations, mechanisms, conditions, sequences, or generative structures that help account for why an observed configuration emerged or changed. Its role is to connect empirical regularities with a disciplined representation of dependence and process. The objective is to distin-

guish explanatory adequacy from descriptive fit and predictive success. The method combines model implications with evidence capable of supporting the proposed explanatory bridge.

A model can explain at several levels. A statistical model can identify a stable conditional relation that narrows plausible explanations. A dynamical model can show how feedback, thresholds, or attractor structure generate a trajectory. A network model can expose how position or topology mediates transmission. An agent-based model can demonstrate how specified local rules are capable of generating an aggregate pattern. A historical model can organize sequences and constraints into a mechanism account. These contributions differ in strength because demonstrating capability, association, temporal compatibility, and empirical operation are distinct evidential achievements.

Explanatory use therefore requires a mapping from formal behavior to substantive mechanism. A simulation that generates polarization under a specified interaction rule establishes a property of the simulated system. An empirical explanatory claim additionally requires evidence that the represented relation or mechanism operates in the target field at the relevant scale and period. A predictive model can also possess explanatory content, but predictive accuracy alone leaves open whether the represented variables track causes, proxies, institutional regularities, or temporary correlations.

Definition 9.393 (Explanatory model claim). An *explanatory model claim* states which represented relations, mechanisms, conditions, or generative structures contribute to understanding an observed pattern, together with the evidence connecting the model's internal organization to the target process and the scope within which that connection is warranted.

Alternative explanations should remain visible. Explanatory adequacy can improve when a model distinguishes observations expected under competing mechanisms or identifies intermediate traces that would discriminate among them. Where several explanations remain compatible with the evidence, the model can still clarify the explanatory space without warranting unique selection.

Proposition 9.394 (Explanatory bridge discipline). *The explanatory use of a model is strengthened when the project separates properties demonstrated within the representation from evidence that the corresponding relation or mechanism operated in the target field, and when competing explanatory bridges remain available for comparison.*

9.24.3 Prediction

Predictive model use estimates future, withheld, unobserved, or otherwise unknown outcomes under specified conditions. Its role is to test whether the model carries information beyond the observations used to construct it and, in some settings, to support anticipation of practically relevant developments. The objective is to make horizon, target, error, regime, and transport assumptions explicit. The method is prospective or out-of-sample where feasible, with evaluation tied to the decision or research function of the prediction.

Prediction can concern different objects. A model can predict a numerical out-

come, an event probability, a transition class, a rank ordering, a relational change, a threshold crossing, or a distribution over possible trajectories. Predictive quality should therefore be evaluated through function-appropriate criteria. An accurate mean forecast can still conceal poor tail behavior. A well-calibrated event probability can have limited usefulness when the intervention threshold is highly asymmetric. A model can predict short-horizon continuation while failing around institutional transformation or critical transitions.

Generative Relational research gives particular attention to rule change. Predictive performance observed within one institutional regime can deteriorate when technologies, classifications, incentives, norms, or network structures change. A prediction architecture should therefore record the horizon over which relevant relations are assumed to remain sufficiently stable and the signals that would indicate model drift or regime transformation.

Definition 9.395 (Predictive use profile). A *predictive use profile* specifies the prediction target, horizon, population or field, training and evaluation relation, error distribution, calibration, relevant regime assumptions, drift indicators, practical or epistemic use, and conditions under which prediction should be suspended or recalibrated.

Prediction can remain epistemically valuable even when it is not used for action. Failed predictions can reveal omitted variables, category change, non-stationarity, or an incorrectly specified generative rule. Conversely, good prediction can identify stable manifestations without resolving underlying mechanisms. The project should preserve both possibilities.

Proposition 9.396 (Function-indexed predictive adequacy). *Predictive adequacy should be evaluated relative to a specified target, horizon, regime, error consequence, and use, with predictive success treated as evidence about that function rather than as automatic confirmation of explanatory or intervention adequacy.*

9.24.4 Counterfactual Exploration

Counterfactual exploration uses models to examine trajectories or outcomes under conditions that differ from the observed history. Its role is to make alternative possibilities analytically explicit. The objective is to distinguish empirically identified counterfactual claims from exploratory model-based alternatives and to preserve the assumptions through which each alternative becomes admissible. The method varies from causal estimation to simulation, historical reconstruction, scenario modeling, and formal comparison of reachable states.

A counterfactual can alter one condition while holding a broader structure fixed, or it can explore a qualitatively different institutional arrangement. These operations have different evidential demands. Local counterfactual estimation may rely on a design that supports a specific comparison. Structural simulation can explore combinations that have never been observed, but its results depend more heavily on assumptions about rules, interactions, and transport. Historical counterfactuals can clarify causal dependence while remaining sensitive to which surrounding relations are treated as invariant.

Counterfactual models are especially useful for revealing constraint. An apparently available option can be unreachable because complementary capacities are absent. A policy can succeed in one modeled branch and fail in another because network topology or institutional sequencing differs. A small change can produce little effect in one regime and a large transition near a threshold. These findings can deepen understanding even when the model is not sufficiently warranted for practical choice.

Definition 9.397 (Counterfactual model record). A *counterfactual model record* identifies the altered condition, preserved conditions, model structure, evidential basis for the counterfactual bridge, represented consequences, sensitivity to alternative assumptions, and the epistemic status of the resulting comparison.

The record should make exploratory status visible. Model-based possibility is analytically informative when it demonstrates coherence, incompatibility, or sensitivity within a specified structure. Practical plausibility additionally depends on empirical feasibility, institutional response, behavioral adaptation, and other relations that may remain outside the model.

Proposition 9.398 (Counterfactual status visibility). *Counterfactual model use should preserve the distinction among empirically identified contrasts, historically reconstructed alternatives, and formally or computationally explored possibilities, because these forms support different strengths of inference and action.*

9.24.5 Theory Critique

Models can function as instruments of theory critique by making theoretical commitments explicit enough to expose inconsistency, omission, non-identifiability, incompatible implications, or failure under empirical confrontation. The role of this use is diagnostic. Its objective is to locate where a theoretical structure encounters difficulty and to determine whether the difficulty concerns parameters, formalization, auxiliary assumptions, categories, empirical scope, or the theory's deeper organizing commitments. The method combines formal derivation, empirical testing, simulation, sensitivity analysis, and comparison with alternative theoretical representations.

Formalization can reveal contradictions that remain obscure in verbal theory. Two propositions can imply incompatible dynamics once written within a shared state structure. A claimed mechanism can require information or coordination unavailable to the modeled actors. A supposed equilibrium can become unstable under perturbations consistent with the theory's own assumptions. An empirical model can show that a predicted relation is absent, reversed, or heterogeneous across contexts. These outcomes create diagnostic pressure without determining the level at which revision should occur.

Section 9.11 established the need to localize discrepancy before repair. Theory critique follows the same discipline. A failed implication can arise because the theory is too broad, because the model is a poor translation of the theory, because measurement is weak, or because the empirical field has changed. Model-based critique is strongest when the project makes these alternative diagnoses explicit.

Definition 9.399 (Model-mediated theory critique). A *model-mediated theory critique* is a documented challenge to a theoretical commitment generated through formal, computational, or empirical representation, together with the implicated assumptions, alternative diagnoses, evidential basis, and possible depths of revision.

Critique can also be generative. Identifying the precise condition under which a theory fails can reveal a missing scale, relation type, historical dependency, or boundary condition. The model therefore becomes a device for locating theoretical incompleteness rather than merely accepting or rejecting an entire theory.

Proposition 9.400 (Localized theoretical critique). *Model-based theory critique becomes more informative when the project identifies which theoretical or translational commitment generates the discrepancy and preserves plausible alternative diagnoses before assigning the failure to the broader theory.*

9.24.6 Theory Generation

Theory generation uses models to produce candidate concepts, mechanisms, relations, invariants, distinctions, or hypotheses that were not fully specified before modeling began. Its role is exploratory and constructive. The objective is to use formal or empirical structure as a source of disciplined theoretical surprise while preserving the distinction between discovery and warrant. The method can involve simulation, pattern discovery, dimensional reduction, model comparison, symbolic formalization, anomaly analysis, or interaction between model behavior and historical or qualitative interpretation.

A model can generate theory in several ways. Simulation can reveal an unexpected transition regime. Statistical analysis can expose a stable interaction that existing categories do not anticipate. Network representation can show that apparent actor attributes are better understood through position. A formal model can reveal an invariant across transformations. A failed model can expose a missing relation. An empirically recurring residual pattern can motivate a new mechanism hypothesis. These outputs become theoretical candidates when researchers interpret their structural significance.

The generative value of modeling does not remove the need for independent confrontation. A pattern discovered because a flexible model searched a large possibility space can reflect data structure, modeling choices, or chance. A mechanism observed in simulation can be an artifact of encoded rules. An elegant formal invariant can arise from representational assumptions with weak empirical relevance. The project should therefore record the origin of the theoretical proposal and then test it through evidence not reducible to the same generative step where feasible.

Definition 9.401 (Model-generated theoretical candidate). A *model-generated theoretical candidate* is a concept, mechanism, relation, distinction, or hypothesis produced through formal, computational, or empirical modeling whose theoretical relevance has been identified but whose warrant remains subject to independent comparison, evidence, and revision.

This definition aligns with the theory-formation architecture of Section 9.22. The model contributes to formation history; it does not by itself settle evidential standing.

Proposition 9.402 (Separation of model generation and theoretical warrant). *Theoretical candidates generated through modeling should retain a provenance link to the model operations that produced them and should acquire stronger theoretical standing only through subsequent evidential, comparative, historical, or formal support appropriate to the claim.*

9.24.7 Theory Transformation

Theory transformation occurs when repeated model–evidence dialogue changes the architecture of an existing theory rather than merely adding a new proposition. Its role is to connect local model revision with broader theoretical development. The objective is to identify when category boundaries, relation types, causal organization, scale assumptions, state representations, or generative rules have changed enough that the theoretical structure itself should be versioned as transformed. The method is comparative across model and theory versions.

Transformation can emerge gradually. Parameter anomalies can accumulate until a missing mechanism becomes visible. Several context-specific exceptions can reveal that a category combines distinct relational positions. A predictive failure around regime change can motivate historically variable rules. Cross-scale inconsistency can lead to a multilevel theory. Formal comparison can show that two previously separate theoretical accounts are special cases of a broader structure. Each pathway changes more than model fit; it reorganizes what the theory treats as an admissible object, relation, or explanatory unit.

A project should preserve the chain linking model revisions to theoretical transformation. This is important because later readers need to distinguish evidence-driven transformation from conceptual preference or retrospective rewriting. The theory-revision records developed in Section 9.22 provide the programme-level destination; the present subsection adds the model-mediated pathway.

Definition 9.403 (Model-mediated theory transformation record). *A model-mediated theory transformation record links consequential model findings and revisions to changes in theoretical categories, relations, mechanisms, scales, boundaries, or generative rules, while preserving the earlier theoretical state and the evidential or formal triggers for transformation.*

Theory transformation can also reduce scope. A model can show that a proposed relation holds only under a restricted topology, period, or institutional configuration. Such narrowing is a substantive theoretical development because it converts an over-general claim into a better specified one.

Proposition 9.404 (Traceable model-to-theory transformation). *When modeling contributes to a change in theoretical architecture, the project should preserve the model findings, alternative interpretations, and revision path that connect the earlier theory to the transformed version, including cases in which transformation narrows rather than expands theoretical scope.*

9.24.8 Decision Support

Decision support marks an important shift in model function because model outputs become inputs to choices with practical consequences. Its role is to inform judgment among feasible actions while preserving the distinction between model output and decision authority. The objective is to specify what part of a decision the model informs, which values and constraints remain external to the model, how uncertainty affects the choice, and what consequences follow from model error. The method integrates empirical and formal analysis with the decision architecture developed in Section 9.23.

A model can support decisions by estimating expected outcomes, identifying constraints, ranking scenarios under stated criteria, revealing distributional effects, detecting risks, or showing where available evidence is insufficient for discrimination. The most useful output is not always a recommended action. A model can improve decision quality by narrowing the option set, identifying dominated choices, exposing a tradeoff, locating a threshold, or demonstrating that several options remain indistinguishable within available uncertainty.

Decision support also changes the meaning of error. In research-dominant use, a model failure can be epistemically productive. In a practical decision, the same failure can impose costs on affected actors. Model evaluation should therefore incorporate consequence asymmetry, reversibility, affected populations, and the availability of monitoring and correction. A moderate predictive error may be acceptable for low-cost planning while unacceptable for an irreversible eligibility decision.

Definition 9.405 (Decision-support model profile). *A decision-support model profile specifies the decision object, model contribution, alternatives considered, relevant outcome dimensions, normative and legal constraints, uncertainty, error consequences, affected actors, contestability, decision authority, monitoring, and conditions for model suspension or override.*

Decision support should preserve human and institutional judgment where the decision includes normative or political choices that cannot be inferred from empirical relations alone. A model can estimate consequences under a value configuration; it does not independently establish which values should govern the decision.

Proposition 9.406 (Model input and decision authority). *A model used for decision support should be treated as a structured input to practical judgment whose influence is proportionate to its validated function, uncertainty, error consequences, and governance conditions, while decision authority and normative responsibility remain explicitly located.*

9.24.9 Scenario Comparison

Scenario comparison uses models to examine several plausible configurations of future conditions, interventions, or environmental responses without requiring a single forecast to dominate the analysis. Its role is to support planning under uncertainty, especially where structural change, path dependence, or multiple interacting processes limit point prediction. The objective is to compare consequences, vulnerabilities, thresholds, and option preservation across a transparent set of scenarios. The

method combines scenario construction with sensitivity, uncertainty, and robustness architectures developed earlier in Chapter 9.

Scenarios can vary exogenous conditions, endogenous responses, institutional rules, behavioral adaptations, timing, scale, or intervention combinations. Their analytical value depends on discriminating structure. A set of scenarios that differs only superficially can create an appearance of breadth without testing consequential uncertainty. Conversely, an unlimited set of possibilities can become uninformative. Scenario design should therefore target uncertainties and structural alternatives that materially affect the decision or research question.

The project should distinguish probability-weighted scenarios from possibility-based scenarios. Some settings support estimated probabilities grounded in repeated observations or well-specified stochastic structures. Other settings involve deep institutional, technological, or political uncertainty for which assigning precise probabilities would overstate knowledge. Scenario comparison can remain useful in those cases by examining robustness, exposure, reversibility, and adaptive capacity across plausible configurations.

Definition 9.407 (Scenario-comparison architecture). A *scenario-comparison architecture* specifies the scenario-generating dimensions, common baseline, structural differences, probability status where applicable, model assumptions, outcome dimensions, uncertainty, comparison criteria, and decision-relevant conclusions that remain stable or vary across scenarios.

Scenario comparison can also reveal the value of delaying commitment, preserving options, or investing in information. A model that cannot identify one preferred pathway can still show that some decisions remain reversible while others close future branches.

Proposition 9.408 (Scenario comparison under structural uncertainty). *Scenario comparison is most informative when scenarios represent consequential structural uncertainty, their probability status is stated rather than implied, and conclusions distinguish robust cross-scenario findings from recommendations that depend on particular modeled futures.*

9.24.10 Intervention Design

Intervention design uses models to represent how an intentional change can enter a relational field, propagate through mechanisms, interact with constraints, and generate intended or unintended consequences. Its role is to connect analytical understanding with actionable design while preserving the difference between simulated efficacy and practical feasibility. The objective is to identify intervention targets, timing, scale, sequencing, complementary conditions, monitoring variables, and plausible side effects. The method integrates generative models with empirical knowledge of institutions, capacities, and affected relations.

An intervention variable in a formal model is not automatically an available action. The represented control may have no feasible institutional analogue, may require unavailable authority, may ignore implementation costs, or may alter actor responses once deployed. A model that assumes direct manipulation of a state vari-

able can therefore overstate practical control. Intervention design should map each modeled intervention to concrete mechanisms of implementation and identify where that mapping is uncertain.

Generative models can nevertheless provide distinctive value. They can reveal that an intervention requires complementary changes, that timing matters because the field is near a threshold, that local improvements propagate adversely elsewhere, or that a small structural change opens a new option space. They can also identify intervention points where direct optimization of an outcome would miss important relational dynamics.

Definition 9.409 (Model-supported intervention design). *A model-supported intervention design links a represented intervention to feasible practical actions, target relations, mechanisms, timing, scale, complementary conditions, expected and unintended consequences, uncertainty, monitoring indicators, reversibility, and governance responsibility.*

Intervention design becomes increasingly application-dominant when practical implementation, allocation, or authorization begins to organize the project more strongly than epistemic learning. Section 9.23 provides the transition criteria. The model can remain the same while its governance burden changes because its output is now coupled to action.

Proposition 9.410 (Feasibility bridge for intervention models). *A model should contribute to intervention design only through an explicit bridge between represented controls and feasible actions, including institutional authority, implementation capacity, behavioral response, uncertainty, side effects, and conditions for monitoring or reversal.*

9.24.11 Risk Assessment

Risk assessment uses models to represent adverse pathways, exposure, vulnerability, uncertainty, and the distribution of possible consequences. Its role is to make risk structure explicit before and during consequential action. The objective is to distinguish modeled hazard from actual exposure, expected loss from tail consequence, quantified uncertainty from unmodeled uncertainty, and aggregate risk from its distribution across actors and time. The method can combine statistical estimation, stress testing, simulation, scenario analysis, historical comparison, and qualitative evidence concerning failure pathways.

Risk models are especially sensitive to model boundaries. Rare harms can arise through mechanisms excluded from a model because they are difficult to quantify. Historical data can underrepresent regimes that have not yet occurred. Correlated failures can invalidate independence assumptions. Institutional adaptation can change exposure after a policy is announced. A precise numerical risk estimate can therefore coexist with substantial uncertainty about the model family, categories, or future regime.

A Generative Relational approach adds attention to generated vulnerability. An intervention can alter networks, capacities, dependencies, classifications, or option spaces in ways that create new exposure. Risk assessment should therefore include

how action changes the field in which later risks emerge, rather than treating vulnerability as a fixed property of actors before intervention.

Definition 9.411 (Relational risk-model profile). *A relational risk-model profile records modeled hazards, exposure pathways, vulnerable relations, consequence distributions, tail behavior, dependencies, model and data uncertainty, generated vulnerabilities, monitoring signals, and repair or reversal capacity.*

Risk models can inform thresholds and safeguards, but they should not silently determine acceptable risk. Judgments concerning whose exposure counts, which harms are tolerable, how distribution is valued, and what precaution is appropriate contain normative and institutional components.

Proposition 9.412 (Risk-model scope and distribution). *Risk-model use should preserve model-boundary uncertainty, distribution of exposure and consequence, plausible generated vulnerabilities, and the normative criteria through which modeled risks become practically acceptable or unacceptable.*

9.24.12 Learning through Action

Learning through action closes the loop between modeling and intervention by treating observed consequences of action as new evidence capable of revising both the model and the intervention. Its role is to support adaptive praxis in fields where important relations can only be learned after limited action occurs. The objective is to design interventions so that learning, monitoring, correction, and stopping remain possible. The method combines intervention, sequential evidence, versioned modeling, and governance of feedback.

Action can reveal relations that observation alone leaves unresolved. A pilot can expose implementation constraints. An intervention can reveal heterogeneous responses. A policy change can generate evidence about adaptation, spillovers, delayed effects, and second-order consequences. A model can then be updated with information generated through the intervention itself. This creates an epistemically powerful cycle, but the cycle is ethically and politically consequential because learning occurs through changes imposed on a real field.

The design should therefore distinguish experimental informativeness from acceptable exposure. An intervention with high information value can still be inappropriate if harms are substantial, irreversible, or imposed without adequate authority. Conversely, a low-risk reversible intervention can be valuable even when it provides only partial information, especially if it preserves future options and supports sequential learning.

Definition 9.413 (Model-mediated learning-through-action cycle). *A model-mediated learning-through-action cycle links a versioned model to an intervention, monitoring plan, observed consequences, discrepancy analysis, model revision, intervention revision, and governance decision concerning continuation, scaling, modification, or cessation.*

Versioning is crucial because action changes the data-generating process. Evidence collected after intervention can reflect the intervention itself, strategic adaptation, institutional learning, or altered measurement. Updating the model without preserving

pre-intervention structure can erase the pathway through which learning occurred.

Proposition 9.414 (Governed adaptive learning). *Learning through action is strengthened when intervention and model revision are jointly versioned, monitoring is tied to explicit discrepancy and harm signals, and continuation or scaling remains subject to governance conditions proportionate to the consequences of further action.*

9.24.13 Change of Model Function across Praxis Modes

The preceding subsections show that model function can change repeatedly within one project. The role of the final subsection is to integrate these changes into an explicit transition architecture. Its objective is to identify when reuse of the same model requires a new validation burden, uncertainty statement, governance pathway, or documentation record because the consequences of its use have changed. The method compares model functions by inferential purpose and practical consequence rather than by mathematical form alone.

A model can move from reconstruction to explanation, from explanation to prediction, from prediction to decision support, or from exploratory simulation to intervention design. Each movement changes the relation between model error and project consequence. The transition can also move in the opposite direction. A model used operationally can be withdrawn into exploratory status after drift, unexpected harm, category change, or evidence that the practical mapping was weaker than assumed. Praxis modes are therefore connected by reversible model-function transitions rather than by a one-way ladder of increasing application.

Definition 9.415 (Model-function transition). *A model-function transition is a documented change in the inferential or practical role assigned to a model that materially alters the evidence, validation, uncertainty, governance, monitoring, or accountability required for warranted use.*

A transition record should identify the previous and proposed functions, what new claim or decision the model will support, which previous validation results remain relevant, which new evidence is required, how uncertainty changes, who becomes affected, which governance body has authority, and what conditions would trigger suspension or return to an earlier function. This record prevents silent escalation, where an exploratory model gradually acquires operational authority without a corresponding change in scrutiny.

Definition 9.416 (Model-function transition record). *A model-function transition record specifies the model version, prior function, proposed function, new inferential or practical claims, transferred and newly required validation, uncertainty profile, affected actors, governance authority, monitoring obligations, and conditions for reversal or further transition.*

The distinction between research-dominant and application-dominant praxis becomes especially clear here. A model can remain within research-dominant praxis while supporting reconstruction, explanation, prediction, critique, theory generation, or limited research-directed intervention. Movement toward application-dominant praxis occurs when model use becomes materially coupled to practical closure, allocation, treatment, authorization, exposure, or consequential non-action. The mathe-

mathematical object may remain unchanged while its social role and accountability structure are transformed.

This observation also explains why model adequacy is function-relative. Internal coherence, historical fit, predictive calibration, explanatory plausibility, counterfactual usefulness, and intervention safety are related but distinct achievements. A project should therefore avoid transferring warrant from one function to another without examining what the transition requires. Section 9.14 provides the uncertainty architecture for that examination, Section 9.17 provides governance, and Section 9.18 provides the documentary lineage through which the transition can later be reconstructed.

Proposition 9.417 (Praxis-sensitive model warrant). *Model warrant should be indexed to function and praxis consequence: when a model acquires a new role that changes the claims supported or the consequences of error, validation, uncertainty communication, governance, monitoring, and accountability should be reassessed for that role.*

The project can operationalize the proposition through a model-use register. For each consequential model version, the register can preserve current function, supported claims, evidence, uncertainty, validation status, decision coupling, affected actors, governance, monitoring, revision conditions, and prior or planned function transitions. Such a register links the model–evidence dialogue of Section 9.11, the decision architecture of Section 9.23, and the governance and documentation architectures of Sections 9.17–9.18.

Formal and empirical models can thus participate in both research-dominant and application-dominant praxis without receiving one fixed epistemic identity. Their contribution depends on the work they perform, the evidence connecting them to a target field, and the consequences attached to their outputs. The next section turns from model-function transitions to the provisional closure of a research cycle, where evidence, uncertainty, unresolved alternatives, preserved materials, and reopening conditions must be brought into a coherent stopping decision.

9.25 Provisional Closure of a Research Cycle

The preceding sections constructed the principal architectures through which an integrated Generative Relational research project can formulate questions, organize evidence and methods, revise models and theories, preserve uncertainty and provenance, govern research action, and contribute to cumulative inquiry. The present section specifies how such a project can reach a warranted stopping point for a particular cycle. Its role is to convert the chapter’s architectures into an explicit closure discipline. Its objective is to identify the conditions under which a research cycle can be stabilized sufficiently for communication, criticism, reuse, and later application while preserving the materials and uncertainty required for future revision. The discussion proceeds through evidential sufficiency, remaining uncertainty, unresolved alternatives, material preservation, revisable conclusions, future questions, reopening conditions, and the status of provisional closure. The method is architectural: closure is represented as a claim- and purpose-relative profile rather than as a universal

Table 9.16: Dimensions of provisional research-cycle closure

Closure dimension	Required project statement	Closure contribution	Characteristic failure if absent
Evidential support	Which claims are supported, by which evidence, at what strength and scope	Makes the stopping threshold claim-relative and criticizable	Premature or indiscriminate closure
Remaining uncertainty	Which uncertainties remain and how they affect claims	Preserves epistemic limits inside the final result	Precision that conceals unresolved dependence
Unresolved alternatives	Which interpretations, models, mechanisms, or categories remain live	Prevents closure from being mistaken for unique selection	Erasure of admissible competing paths
Preserved materials	Which evidence, code, records, versions, and provenance are retained	Enables reconstruction, reuse, and later re-epistemization	Irreversible loss of the basis for revision
Revisable conclusions	What is concluded, with scope, status, and revision conditions	Makes conclusions usable without presenting them as final	Either vague non-commitment or self-sealing assertion
Future questions	Which unresolved questions follow from the completed cycle	Converts residual uncertainty into an organized research frontier	Generic calls for further research without continuity
Reopening conditions	Which new evidence, changes, failures, or consequences trigger reassessment	Connects closure to future correction	Closure insulated from materially relevant change
Closure status	What exactly is closed, for what purpose, and what remains open	Distinguishes cycle completion from epistemic finality	Confusion between stopping and completion of knowledge

threshold of certainty.

Definition 9.418 (Provisional research-cycle closure). *Provisional research-cycle closure* is the documented stabilization of a bounded phase of inquiry when its principal claims have reached support sufficient for their stated purpose, its remaining uncertainties and alternatives are explicit, its consequential materials and lineages are preserved, and conditions capable of reopening the inquiry remain identifiable.

Definition 9.418 treats closure as a research status rather than a declaration that the object has been exhausted. A project can close one cycle while leaving several questions unresolved. It can also stabilize different claims at different strengths. A descriptive claim, a mechanism claim, a historical interpretation, and a model intended for decision support can require different forms and levels of support. Closure therefore attaches to specified claims, purposes, scopes, and consequences.

Table 9.16 summarizes the principal dimensions of the closure architecture. The dimensions are jointly relevant, although their required depth varies with the type and consequence of the research output.

The table also clarifies the relation between closure and the architectures developed earlier in the chapter. Sensitivity analysis in Section 9.12 identifies dependence; robustness architecture in Section 9.13 identifies forms of stability; uncertainty architecture in Section 9.14 records residual openness; historical re-epistemization in Section 9.15 preserves future reconstructability; and Sections 9.18–9.21 provide the documentation, reproducibility, reuse, and cumulative-research infrastructure through which a closed cycle can later be reopened without losing its lineage. Closure is therefore an integration point rather than an additional test applied at the end.

9.25.1 Sufficient Evidential Support

Sufficient evidential support is the first closure condition because a research cycle requires claims stable enough to be stated, criticized, compared, and used. Its role is to prevent both premature stabilization and indefinite deferral. The objective is to establish a claim-relative threshold that reflects the type of inference, intended use, available alternatives, uncertainty, and consequences of error. The method is to connect each consequential claim to an evidential support profile rather than applying one undifferentiated standard across the project.

The word *sufficient* is purpose-indexed. A preliminary historical reconstruction can reasonably close with incomplete archives if the missing record is explicit and the claim remains correspondingly narrow. A strong causal attribution requires a different evidential architecture. A model used only to generate theoretical candidates can close a research phase with weaker empirical validation than the same model would require before influencing consequential decisions. Section 9.24 therefore matters directly: model function helps determine the evidential burden relevant to closure.

Sufficiency also concerns the relation among evidence streams. Large quantities of dependent evidence do not necessarily provide stronger support than several genuinely differentiated pathways. Conversely, a small but highly diagnostic observation can materially alter a closure judgment. The project should therefore evaluate relevance, provenance, independence, contradiction, representational coverage, and scope rather than counting observations alone.

Definition 9.419 (Closure-support profile). A *closure-support profile* records a target claim, its intended research function, supporting and countervailing evidence, dependence among evidential pathways, remaining uncertainty, relevant alternatives, scope conditions, and the project-relative reason the present support is judged sufficient for closure.

The profile makes closure criticizable. Another investigator can disagree with the threshold while seeing how it was reached. The profile also permits uneven closure across a project. Some claims can be stabilized strongly, others provisionally, and others retained only as hypotheses or open questions.

Proposition 9.420 (Claim-relative closure sufficiency). *Evidential sufficiency for provisional closure should be assessed relative to the claim's inferential type, scope, intended use, uncertainty, plausible alternatives, and consequences of error; support sufficient for one research function does not automatically authorize closure for another.*

Proposition 9.420 prevents closure from inheriting an evidential status that was established for a different purpose. A result can therefore be complete enough for publication as an exploratory reconstruction while remaining explicitly incomplete for prediction or intervention.

9.25.2 Explicit Remaining Uncertainty

Remaining uncertainty is part of a closed research cycle because closure stabilizes a claim under known limits rather than removing every source of indeterminacy. Its role is to preserve the uncertainty architecture developed in Section 9.14 inside the project's terminal outputs. The objective is to prevent the compression that often

occurs when a long research process is summarized into a small number of headline conclusions. The method is to carry forward those uncertainties that materially affect interpretation, scope, transfer, model function, or future action.

A closure record should therefore distinguish uncertainty that has been reduced from uncertainty that has merely been accepted. Measurement uncertainty can narrow through improved instruments. Model uncertainty can remain because several structures fit the available record. Historical uncertainty can persist because relevant traces are missing. Normative uncertainty can remain because several evaluative premises are defensible. Generative uncertainty can remain because a mechanism is plausible while its future activation conditions are unstable. These forms should not be merged into one verbal qualifier.

Closure can also increase the importance of communicating uncertainty. During exploratory inquiry, uncertainty can remain distributed across notebooks, alternative models, and internal discussion. Once conclusions travel into other projects, policy settings, educational materials, or cumulative research, downstream users can encounter only the stabilized result. The closure record should therefore preserve uncertainty in a form capable of traveling with the claim.

Definition 9.421 (Closure uncertainty statement). *A closure uncertainty statement identifies the uncertainties that materially remain at the end of a research cycle, their location in the evidential or inferential architecture, their effect on the stabilized conclusions, and the kinds of future information or analysis that could reduce, transform, or reclassify them.*

Proposition 9.422 (Uncertainty retention at closure). *Provisional closure is epistemically stronger when materially relevant uncertainty remains attached to the claims it qualifies, rather than being detached from those claims during synthesis, publication, reuse, or transfer into later praxis.*

This proposition does not require that every uncertainty receive equal emphasis. Closure demands prioritization. The project should retain those uncertainties capable of changing the interpretation, strength, boundary, or consequence of the claim, while lower-level uncertainty can remain in supporting records.

9.25.3 Unresolved Alternatives

Unresolved alternatives concern interpretations, mechanisms, models, category systems, boundary choices, or theoretical paths that remain admissible when a research cycle closes. Their role is to preserve epistemic plurality where the available evidence does not warrant unique selection. The objective is to distinguish alternatives that have been rejected, alternatives that remain live, and alternatives that have been suspended because current evidence cannot discriminate among them. The method builds on the cross-method adjudication and multiple-model reasoning developed in Sections 9.10 and 9.11.

Alternatives can remain unresolved for different reasons. Two models can be observationally similar within the available data. Historical evidence can support several causal sequences because an intermediate record is absent. Interpretive accounts can emphasize different dimensions of the same field. A category dispute can

remain non-operative for the current claim while becoming important under another scale or intervention. These situations call for different closure statements.

The project should therefore assign alternatives a status. An alternative can be *disfavored* because evidence weighs against it; *conditionally retained* because it remains plausible under specified assumptions; *suspended* because the present inquiry lacks discriminatory evidence; or *retired* because its central commitments have become incompatible with the record or research purpose. Status should remain revisable when new evidence changes the comparison.

Definition 9.423 (Alternative-status register). An *alternative-status register* records consequential competing interpretations, models, mechanisms, category schemes, or theoretical paths together with their current status, evidential basis, differentiating assumptions, unresolved comparison points, and conditions under which their status should be reassessed.

Proposition 9.424 (Alternative-preserving closure). A *research cycle can close while multiple alternatives remain live when the project's primary claims are sufficiently stabilized for their stated purpose and the unresolved alternatives, their implications, and the limits of present discrimination remain explicit.*

Closure therefore need not force a synthetic conclusion where the evidential architecture supports plurality. Preserving alternatives can increase cumulative value by giving later research a defined comparison space rather than requiring it to reconstruct discarded possibilities from scattered traces.

9.25.4 Preserved Materials

Preserved materials provide the material basis for future criticism, reproduction, reuse, and re-epistemization. Their role at closure is to ensure that the stabilized result does not become detached from the records through which it was produced. The objective is to preserve a reconstructible project state proportionate to the significance and future use of the claims. The method integrates the historical preservation, documentation, provenance, and reuse architectures developed in Sections 9.15 and 9.18–9.20.

Preservation should include more than the files that directly support the final claim. Relevant materials can include raw or source data where ethically and legally preservable, transformation scripts, coding schemes, model versions, parameter records, decision logs, assumption registers, rejected specifications, negative results, alternative interpretations, documentation of access conditions, and contextual records needed to understand what the evidence meant at the time of inquiry. The required set depends on the project.

Material preservation also has selective limits. Indiscriminate retention can create privacy, security, governance, and interpretive problems. Some source material cannot be shared or retained indefinitely. Some intermediate files have little epistemic value. The closure task is therefore to distinguish preservation necessary for lineage from accumulation without a defined future function.

Definition 9.425 (Closure preservation set). A *closure preservation set* is the documented collection of evidential, computational, interpretive, theoretical, and gover-

nance materials judged necessary to reconstruct the principal claims, transformations, alternatives, and decisions of a completed research cycle within applicable ethical, legal, and practical constraints.

Where material cannot be retained, the project should preserve metadata or a loss record where feasible: what existed, why it is unavailable, which claims depend upon it, and what later reconstruction will therefore remain impossible or uncertain. Preservation quality is thus measured partly by the visibility of its own gaps.

Proposition 9.426 (Reconstructible material closure). *Closure supports future revision when the preserved project state is sufficient to reconstruct the main evidential and inferential pathways of the completed cycle, including consequential transformations and known preservation gaps.*

9.25.5 Revisable Conclusions

Revisable conclusions convert a completed research cycle into explicit claims that can circulate without losing their conditions of validity. Their role is to balance usability and openness. The objective is to state conclusions strongly enough for criticism, comparison, teaching, cumulative research, and possible application while retaining the scope, uncertainty, alternatives, and reopening conditions that delimit their warrant. The method is to treat each consequential conclusion as a versioned epistemic object.

A conclusion can be revisable without becoming vague. “Evidence remains incomplete” is not a substitute for specifying what the project actually supports. Conversely, a precise estimate or mechanism statement can remain revisable when its evidential basis, scope, historical period, representation, and uncertainty are explicit. Revisability concerns the relation between a claim and the conditions under which it was stabilized.

The conclusion record should therefore distinguish claim content from claim status. A mechanism can be strongly supported within one field and period while its transfer remains open. A theoretical proposition can be retained as a productive organizing hypothesis without being presented as an established empirical regularity. A model can be adequate for reconstruction but not for decision support. These distinctions preserve the function-indexed warrant developed in Section 9.24.

Definition 9.427 (Revisable conclusion record). *A revisable conclusion record states a stabilized claim together with its epistemic status, scope, evidential basis, uncertainty, relevant alternatives, version, intended uses, excluded stronger interpretations, and conditions under which revision should be considered.*

Proposition 9.428 (Explicit conclusion status). *A conclusion becomes more reusable and criticizable when its substantive content is accompanied by an explicit statement of epistemic status and scope, allowing later users to distinguish what the cycle established from what it left conditional, exploratory, or unresolved.*

This proposition also protects against retrospective inflation. As a result is cited or reused, its qualifiers can disappear. Versioned conclusion records give later researchers a stable source against which stronger downstream formulations can be checked.

9.25.6 Future Questions

Future questions transform residual uncertainty into an organized frontier for subsequent inquiry. Their role is to connect cycle closure with cumulative research rather than allowing closure to end in a generic statement that further research is desirable. The objective is to derive questions from concrete unresolved relations, evidential gaps, competing alternatives, failed translations, sensitivity results, and newly generated possibilities. The method is to link each future question to the part of the completed architecture that gives it significance.

Future questions can arise from several sources. A sensitivity analysis can identify a boundary whose alteration changes the conclusion. A model comparison can reveal two structures that current evidence cannot distinguish. A historical reconstruction can expose an archival gap. A research-directed intervention can generate an unexpected feedback effect. A category revision can make older evidence newly ambiguous. A negative result can narrow one path while revealing another. These are stronger starting points than undifferentiated appeals for more data.

Future questions also differ in priority. Some are necessary to test the stability of a core claim. Some concern extension into new contexts or scales. Others are theoretically generative but less urgent. Still others become important only if a practical application is contemplated. The closure record should preserve these differences without converting them into a permanent research agenda.

Definition 9.429 (Closure-derived research frontier). *A closure-derived research frontier is a structured set of future questions linked to unresolved uncertainties, alternatives, evidential gaps, theoretical tensions, contextual extensions, or practical consequences identified during the completed research cycle.*

Proposition 9.430 (Lineage-linked future questions). *Future questions contribute more strongly to cumulative research when their relation to the completed cycle is explicit enough to show which uncertainty, alternative, contradiction, or generative possibility motivates their pursuit.*

The research frontier remains open to questions that were not anticipated by the current cycle. Historical change, new technologies, new affected groups, or new theoretical languages can make previously invisible questions salient. The point of a closure-derived frontier is continuity, not control over future inquiry.

9.25.7 Conditions for Reopening

Conditions for reopening specify how a closed research cycle remains vulnerable to materially relevant change. Their role is to turn revisability from a general virtue into an operational commitment. The objective is to identify triggers whose occurrence should prompt reassessment of one or more stabilized claims. The method is to link reopening conditions to the claim's evidence, model, categories, historical context, intended use, and consequence profile.

Reopening can be triggered by new evidence, successful counterexamples, replication failure, newly accessible archives, model failure, category instability, changed institutional conditions, distributional consequences, methodological innovation, or transformation of the underlying research object. A claim can also require reopen-

ing when its function changes. A model stabilized for exploratory explanation may need renewed assessment when proposed for operational decision support, even if no new evidence has appeared.

Triggers should be material rather than exhaustive. A project does not need to re-open because every new observation differs slightly from the earlier record. The relevant issue is whether the change can alter the claim's interpretation, support, scope, or consequence. Reopening conditions can therefore include thresholds, qualitative events, or governance decisions.

Definition 9.431 (Reopening trigger). A *reopening trigger* is a specified evidential, methodological, theoretical, historical, practical, or governance change whose occurrence is judged capable of materially altering the warrant, scope, interpretation, or consequence of a provisionally closed research claim.

Definition 9.432 (Research-cycle reopening protocol). A *research-cycle reopening protocol* records relevant reopening triggers, monitoring or discovery pathways where applicable, responsible actors, the claims potentially affected, the first level of reassessment required, and the conditions under which a new research cycle should be initiated.

Proposition 9.433 (Materiality-sensitive reopening). *Reopening discipline is strengthened when triggers are tied to changes capable of materially affecting the closed claim and when the required depth of reassessment is proportional to the location and consequence of that change.*

This proportionality connects reopening to the revision hierarchy of Section 9.11. A changed parameter may require local updating. A failed category can propagate through data coding, models, interpretations, and theory. A transformed field can require a new research object. The reopening protocol should therefore specify an entry point without assuming in advance how deep the eventual revision will become.

9.25.8 Provisional Closure and Epistemic Continuation

The final component integrates the preceding conditions into a project-level closure status. Its role is to distinguish the completion of a research cycle from completion of knowledge about the object. The objective is to make closure communicable as a bounded achievement: the project can state what has been stabilized, why work can stop at the present phase, what remains open, and how later inquiry can continue from the preserved state. The method is to assemble the closure-support profiles, uncertainty statements, alternative-status register, preservation set, revisable conclusions, future research frontier, and reopening protocol into one closure record.

Definition 9.434 (Research-cycle closure record). A *research-cycle closure record* is the integrated project record that identifies the cycle being closed, its principal stabilized claims, closure-support profiles, remaining uncertainties, unresolved alternatives, preservation set, revisable conclusions, future questions, reopening triggers, responsible custodians, and the scope and purpose for which closure is presently warranted.

The record can support several closure states. A cycle can close with strong conver-

gence around its principal claims. It can close with qualified plurality when several alternatives remain admissible but the project's narrower objectives have been met. It can close negatively when the principal result is that a proposed relation, model, or mechanism lacks support within the investigated domain. It can also close because the present design has reached an evidential boundary that cannot be crossed with available records, access, or methods. These states should remain distinguishable because they generate different future questions.

Closure also has a temporal structure. A manuscript submission, dataset release, model freeze, or completed field phase can require local closure while the broader project continues. Conversely, a project can close institutionally while some of its claims remain actively contested in the wider research programme. The research-cycle closure record should therefore state the level at which closure operates.

Proposition 9.435 (Closure with epistemic continuation). *A research cycle reaches warranted provisional closure when its current purpose can be completed without concealing materially relevant uncertainty, alternatives, or dependency, and when the records necessary for criticism, reuse, and future reopening remain sufficiently preserved.*

Proposition 9.435 provides the chapter's stopping discipline. Closure is neither maximal certainty nor permanent suspension. It is a governed transition from active reconstruction to a stabilized research state that remains connected to future inquiry. The cycle ends because the present epistemic purpose has been met to a stated standard, while the project retains enough structure for later evidence, interpretation, or practical consequence to alter what has been stabilized.

Section 9.25 therefore completes the project-level research cycle constructed across Chapter 9. The final section of the chapter can now step back from individual design components and consolidate what the research-dominant praxis block has established, what remains outside its competence, and how its outputs pass into the next part of the book without erasing the continuing presence of research within later application-dominant praxis.

9.26 Completion of the Research-Dominant Praxis Block

The preceding chapters have constructed research-dominant praxis from four connected levels: the praxis conditions under which inquiry is organized, the methodologies through which relations are investigated, the methodologies through which generative processes are reconstructed, and the project architecture through which these resources are coordinated into a complete research cycle. The role of the present section is to close this block without converting its completion into either epistemic finality or a claim that research alone can resolve the practical and substantive tasks that follow. Its objective is to state what the block has established, delimit its competence, specify how its outputs travel into substantive Generative Relational Economics and application-dominant praxis, preserve the mutual presence of research and application across praxis modes, and establish the correct transition into Part IV. The discussion proceeds from block-level consolidation and scope boundaries through research-output transfer, cross-praxis persistence, immediate

transition to application-dominant praxis and methodology, and preparation for the later return to the economic domain. The method is architectural and synthetic: the emphasis is on relations among the preceding components, on the interfaces through which they travel, and on the conditions under which their functions change.

Definition 9.436 (Integrated research-dominant praxis architecture). An *integrated research-dominant praxis architecture* is a revisable configuration in which research orientation, relational and generative methodologies, project design, evidential adjudication, uncertainty, governance, documentation, cumulative memory, theory development, research decision, and provisional closure are coordinated around the principal practical task of producing and revising warranted knowledge.

Definition 9.436 summarizes the block without reducing it to a linear workflow. A research project can move recursively among question formation, representation, data construction, methodological comparison, model revision, theory development, and renewed field encounter. Section 9.1 represented that recursion at the project level; Sections 9.10–9.15 made conflict, model–evidence dialogue, sensitivity, robustness, uncertainty, and historical re-epistemization explicit; and Sections 9.16–9.25 added AI-assisted workflow, governance, documentation, reproducibility, reuse, cumulative research, theory development, research decision, changing model function, and provisional closure. The completion of the block therefore concerns a sufficiently articulated research architecture rather than completion of knowledge about any particular economic or social object.

Table 9.17 summarizes the principal layers that the completed block contributes to the remainder of the book. The table emphasizes carry-forward objects because the next stages of the book do not begin from an empty methodological field. They inherit questions, evidential relations, models, uncertainty, governance structures, and reopening conditions already produced within research-dominant praxis.

The table also clarifies a structural feature of the book. The research-dominant praxis block does not constitute a detachable methodological appendix to substantive economics. Its outputs become conditions under which later substantive and practical claims can be stated with appropriate scope, provenance, and revisability. At the same time, later economic and practical inquiry can expose weaknesses in the present architecture and return pressure to earlier categories, methods, and theories. Completion therefore establishes an interface for continuing movement rather than a one-directional passage.

9.26.1 Established Architecture of Research-Dominant Praxis

The first task of block completion is to identify what has actually been established. Its role is to prevent the long methodological development of Parts II and III from being remembered only as a collection of techniques. The objective is to state the common architecture that now links epistemology, praxis, method, project design, and closure. The method is synthetic: the central commitments are reconstructed according to the work they perform within a research cycle rather than according to the order in which they first appeared.

The block has first established that research is a form of praxis. Research questions, object definitions, evidential inclusions, models, classifications, field relations, pub-

Table 9.17: Carry-forward architecture of the completed research-dominant praxis block

Architectural layer	Principal contribution	Carry-forward object	Later function
Research praxis	Specifies orientation, principal contradiction, situated agency, judgment, incompleteness, institutional conditions, and revisability	Praxis configuration and responsibility structure	Grounds later distinctions between research-dominant and application-dominant phases
Relational methodology	Provides procedures for specifying, reconstructing, comparing, measuring, interpreting, and validating relations	Relational objects, evidence structures, boundary and scale choices	Supports substantive identification of economic subjects, institutions, resources, and relational structures
Generative methodology	Provides procedures for mechanisms, trajectories, feedback, criticality, transformation, counterfactuals, and generative attribution	Generative claims, process models, trajectory structures, sensitivity and robustness profiles	Supports analysis of value generation, capacity formation, institutional change, power, and economic dynamics
Integrated project design	Coordinates questions, cases, fields, data, representations, method portfolios, models, adjudication, uncertainty, governance, and closure	Versioned project architecture and claim lineage	Enables transfer into practical decision, intervention, reuse, and cumulative research without losing epistemic status
Closure and memory	Preserves uncertainty, alternatives, provenance, negative results, competing theories, and reopening conditions	Closure record, archives, registries, lineage records, future questions	Makes later application and substantive theory revisable rather than dependent on decontextualized results

lication choices, and acts of preservation all alter what later inquiry can encounter and how other actors can respond. Research-dominant praxis is therefore differentiated from application-dominant praxis by its principal orientation and organizing contradiction, not by an absence of action. The characteristic task is to stabilize concepts, representations, methods, and claims sufficiently for inquiry to proceed while preserving their capacity to be revised by counterevidence, historical transformation, and generative novelty.

Second, the block has established an epistemic architecture in which manifestations, records, measurements, testimony, traces, and model outputs are treated as mediated accesses to relational reality. Evidence is therefore connected to claims through explicit inferential and representational relations. Relational identification and generative attribution receive different evidential burdens. Categories, scales, boundaries, and representations are research choices whose consequences should remain visible. This architecture supports empirical discrimination without requiring a claim that one representational language exhausts the object.

Third, the block has established methodological plurality with recursive correction. Historical, interpretive, qualitative, quantitative, formal, computational, legal, and intervention-based approaches can contribute differentiated forms of access. Their plurality does not imply equal warrant in every project, and methodological comparison does not require their translation into one common metric. Section 9.10 developed project-level adjudication for convergence, divergence, contradiction, unequal evidential strength, method-specific blind spots, and irreducible disagreement. Methodological integration is consequently organized through function, evidence,

translation, and contestability rather than prestige or automatic synthesis.

Fourth, the block has established a generative orientation. Inquiry concerns not only which relations exist but also what those relations contribute to later capacities, constraints, transformations, trajectories, and possibilities. Mechanisms, feedback, path dependence, delayed effects, criticality, attractors, multiscale processes, and transformation of generative rules become legitimate research objects when the evidential architecture can support them. Formal and computational representations can clarify such structures while remaining subject to ontological restraint and empirical interpretation.

Fifth, Chapter 9 has established the research project itself as an analyzable architecture. Questions, cases, fields, data, representations, methods, models, interpretations, decisions, and closure conditions can be documented as connected choices. Sensitivity and robustness can be differentiated; uncertainty can be layered; models can be revised at parameter, structural, categorical, methodological, or theoretical depth; AI operations can receive role-specific verification; and governance can connect authority with answerability. The result is a project whose inferential history can remain reconstructible after its active phase has ended.

Finally, the block has established closure without finality. Section 9.25 permits a research cycle to stop when support is sufficient for its stated purpose while uncertainty, alternatives, materials, future questions, and reopening conditions remain explicit. This makes research outputs usable without presenting them as epistemically complete. The architecture thereby resolves neither the object nor the research programme. It establishes a disciplined state from which later inquiry and action can proceed.

Proposition 9.437 (Block-level research completion). *The research-dominant praxis block is complete for the present book when it provides a sufficiently explicit architecture for producing, comparing, revising, governing, documenting, closing, and reopening research claims while preserving the distinction between epistemic warrant and the practical authority later attached to those claims.*

Proposition 9.437 makes the meaning of completion narrow. It does not assert that every methodology has been covered or that the architecture is universally adequate. It states that the book now possesses enough research infrastructure to proceed to application-dominant praxis and, later, substantive GRE without silently importing an unexamined model of knowledge production.

9.26.2 Scope and Boundaries of Research-Dominant Praxis

The second task is to delimit the competence of the completed block. Its role is to prevent methodological sophistication from being converted into practical or normative authority that research alone cannot supply. The objective is to identify boundaries concerning practical decision, normative choice, future contingency, field transformation, and institutional legitimacy. The method is scope-sensitive: each boundary is treated as a relation between what research can warrant and what later praxis still has to decide.

Research-dominant praxis can narrow uncertainty, reconstruct mechanisms,

identify historical constraints, compare models, expose trade-offs, and clarify consequences. It can also identify where evidence is weak or where several interpretations remain live. These capacities can materially improve later practical judgment. They do not by themselves determine what should be done. A well-supported causal relation does not uniquely specify a legitimate intervention. A robust prediction does not determine an acceptable distribution of error. A historical reconstruction does not settle how conflicting claims should be weighted in present institutions. A formally coherent objective function does not create the normative warrant for optimizing it.

The same boundary applies to value and justice. Research can reconstruct how evaluative categories emerged, identify who bears costs, examine which capabilities or relations are affected, compare normative premises, and test empirical claims contained within normative arguments. Practical judgment can still require choices among plural values, rights, responsibilities, institutional mandates, and distributions of risk that remain underdetermined by empirical evidence. The uncertainty architecture of Section 9.14 therefore includes normative uncertainty rather than assuming that improved measurement will eliminate it.

Future contingency provides another boundary. Generative inquiry can identify mechanisms, thresholds, feedback structures, possible attractors, and historically conditioned trajectories. Near critical transitions or under structural transformation, precise future realization can remain highly sensitive. A research project can sometimes establish that a field is structurally difficult to predict more strongly than it can predict a unique trajectory. This result can be practically important, but it cannot remove the necessity of deciding under uncertainty.

Research also operates within institutional and relational conditions that it cannot fully externalize. Access, funding, data ownership, language, disciplinary evaluation, computational infrastructure, legal restrictions, and relations with participants shape what can be studied and preserved. Reflexive documentation can make these conditions more visible, while no documentation architecture can guarantee that every excluded relation has been identified. The boundary is therefore partly epistemic and partly institutional.

Definition 9.438 (Research-dominant praxis boundary profile). *A research-dominant praxis boundary profile records the principal respects in which a completed research configuration remains unable to determine practical ends, normative priorities, future trajectories, institutional legitimacy, or consequences outside the scope of its evidence and representations.*

The boundary profile should travel with consequential research outputs. It prevents downstream users from treating a detailed research product as universally action-guiding. It can state, for example, that a model identifies distributional consequences without ranking them, that a field study supports one mechanism in a bounded context, or that a simulation explores structurally possible regimes without estimating their empirical probability.

Proposition 9.439 (Non-substitutability of research closure). *Provisional research closure does not substitute for practical legitimacy, normative judgment, institutional authorization, or responsibility for consequences when a research output becomes coupled to application-dominant action.*

This proposition gives the block an explicit stopping boundary. Research can inform later praxis and can sometimes reveal that certain practical options lack evidential support. It does not thereby absorb application-dominant praxis into research methodology. The next part of the book is necessary precisely because action under incomplete knowledge introduces a distinct configuration of judgment, responsibility, timing, risk, reversibility, and consequence.

9.26.3 Research Outputs for Substantive GRE

The third task concerns the eventual construction of substantive Generative Relational Economics. Its role is to specify what the research-dominant block contributes to later economic theory without allowing methodological categories to predetermine economic ontology. The objective is to identify the research outputs that can support later analysis of economic subjects, institutions, resources, capacities, relations, value, power, and generative processes. The method is translational: outputs are treated as inputs whose status and lineage remain attached as they enter substantive inquiry.

Substantive GRE requires more than a vocabulary of relations. It requires evidence and argument concerning which relations are economically consequential, how they are constituted, how they persist or transform, what capacities they enable or constrain, and how heterogeneous forms of value are generated, converted, circulated, captured, dissipated, or regenerated. The relational methodologies of Chapter 7 provide tools for identifying and characterizing these structures. The generative methodologies of Chapter 8 provide tools for examining their contribution to subsequent change. Chapter 9 provides the design architecture through which the relevant evidence, models, disagreements, and uncertainties can be integrated.

A later economic concept should therefore be able to receive several kinds of research support. Historical inquiry can reconstruct how a category acquired its institutional meaning. Qualitative and interpretive inquiry can identify meanings, practices, and relational mechanisms. Quantitative analysis can characterize distributions, dependence, heterogeneity, and change. Network or spatial analysis can reveal structural position and accessibility. Formalization can make assumptions and generative consequences explicit. Simulation can examine possible trajectories under specified structures. These contributions are complementary when their inferential roles remain distinguishable.

The research block also supplies negative discipline. It provides reasons to resist treating observed monetary quantities as exhaustive measures of value, treating legal ownership as the full structure of control, treating individuals as isolated units when relational dependence matters, or treating stable categories as historically invariant when evidence indicates transformation. Such discipline does not determine the substantive GRE categories in advance. It establishes the evidential standards under which those categories can later be proposed and revised.

Definition 9.440 (Substantive GRE research-input bundle). A *substantive GRE research-input bundle* is a lineage-preserving collection of relational specifications, generative claims, evidence structures, historical reconstructions, formal or empirical models, uncertainty and robustness profiles, competing interpretations, and

scope conditions that can support the development or revision of a substantive economic concept or theory.

The bundle is intentionally heterogeneous. A substantive concept need not be supported by every method, yet its development should remain connected to the evidential forms that make its claims meaningful. A relational economic subject, for example, can require conceptual argument, institutional evidence, historical development, empirical patterns, and formal representation at different stages. The bundle permits those supports to accumulate without being compressed into one universal measure of validity.

Proposition 9.441 (Lineage-preserving substantive transfer). *Research outputs contribute more strongly to substantive GRE when the evidential, representational, methodological, and uncertainty relations that support them remain visible after they are incorporated into economic concepts, models, and theoretical propositions.*

This proposition protects substantive theory from retrospective simplification. A concept can become increasingly central to GRE while preserving the history of the evidence and disagreement through which it was constructed. Later chapters can therefore revise the theory without having to reconstruct its entire evidential genealogy from outside the book.

9.26.4 Research Outputs for Application-Dominant Praxis

The fourth task concerns transfer into application-dominant praxis. Its role is to specify how research outputs can become inputs to decisions and interventions without carrying their research warrant unchanged into a new practical function. The objective is to define a transfer architecture that preserves epistemic status while adding consequence-sensitive requirements. The method is interface-based: the research object and the practical use are documented as distinct stages connected by an explicit transfer relation.

Section 9.24 established that the same model can change function without changing mathematical form. The same principle applies more broadly. A classification constructed for analysis can become an eligibility rule. A historical risk association can become a screening variable. A network measure can become an intervention target. An interpretive category can become an administrative label. A causal estimate can influence allocation. In each case, the transition changes who is affected, what counts as error, how disagreement can be contested, and how quickly correction must occur.

Research outputs therefore enter application as structured inputs rather than ready-made decisions. Their support, uncertainty, alternatives, scope, and known sensitivities should remain visible. Additional practical information can also become necessary: feasible action sets, institutional constraints, distribution of benefits and harms, timing, reversibility, monitoring capacity, affected actors, rights, legitimacy, and responsibility. A conclusion that was adequate for publication can be inadequate for a high-stakes intervention because the consequence structure has changed.

Definition 9.442 (Research-to-application transfer record). *A research-to-application transfer record documents a research output proposed for practical use, its original*

research function and warrant, the new practical function, affected relations, additional evidence and normative premises required, uncertainty and error consequences, governance conditions, monitoring needs, and conditions for suspension, revision, or return to research.

The transfer record preserves a boundary that is easily lost in institutional practice. A result can be highly warranted as evidence and still require substantial additional judgment before practical use. Conversely, practical urgency can justify acting before research uncertainty is substantially reduced, provided the uncertainty, risks, reversibility, and responsibility structure are explicitly governed. Application-dominant praxis therefore begins from research without being reducible to it.

Proposition 9.443 (Function-sensitive research transfer). *When a research output acquires a consequential practical function, its earlier epistemic warrant should be treated as an input to renewed practical evaluation rather than as sufficient authorization for the action attached to it.*

Proposition 9.443 also protects research from responsibility displacement. Institutions cannot legitimately represent a practical choice as if it were merely dictated by evidence when the action also depends on normative priorities, institutional authority, thresholds, and distributions of consequence. The research contribution remains important precisely because its status is kept distinct.

9.26.5 Persistence of Research within Application

The fifth task is to preserve research functions after application begins. Its role is to prevent the distinction between praxis modes from becoming a false temporal sequence in which inquiry ends when action starts. The objective is to identify the research activities that remain necessary within application-dominant praxis. The method is recursive: application is treated as a changing field that can generate new evidence, new uncertainty, and new demands for conceptual or methodological revision.

Practical action changes the object of inquiry. An intervention can modify incentives, relationships, expectations, institutional routines, infrastructures, and available options. A classification can reorganize behavior around the category. A predictive system can alter the distribution of cases later used to evaluate it. A policy can generate new strategic responses. Monitoring these transformations is partly a practical responsibility and partly a research task because the evidence necessary to understand the intervention emerges through its implementation.

Research therefore persists through monitoring, evaluation, causal and interpretive reconstruction, model revision, detection of distributional effects, identification of unanticipated relations, and historical documentation of the intervention itself. Learning through action, developed in Section 9.24, is one organized form of this persistence. Application can also reveal that the earlier research object was incompletely specified or that a category changes meaning after institutionalization.

Definition 9.444 (Embedded research function). *An embedded research function is an epistemically oriented activity retained within application-dominant praxis to observe, reconstruct, test, interpret, document, or revise claims about the field and the*

effects of ongoing action.

An embedded research function can use the same methods developed in the research block, but its access conditions can differ. Data produced during implementation may be endogenous to the intervention. Participants can adapt strategically. Ethical obligations can limit experimentation. Operational systems can constrain what is measurable. Evaluation can also become politically consequential. Research within application therefore requires renewed attention to provenance, interference, category change, and institutional power.

Proposition 9.445 (Research continuity within application). *Application-dominant praxis retains a research requirement whenever consequential action generates new evidence, transforms the research object, changes the meaning of earlier categories or models, or creates uncertainty that can materially affect continued action.*

This proposition prevents practical closure from becoming epistemic closure. An intervention can be justified for a period while remaining subject to active learning and revision. The persistence of research therefore supports adaptive application, but it does not guarantee that all application can be converted into experimentation. Some practical relations impose ethical, legal, or distributive constraints on how learning can occur.

9.26.6 Persistence of Application within Research

The complementary task is to preserve awareness of application-like functions already present within research-dominant praxis. Its role is to prevent research from being represented as a consequence-free epistemic space. The objective is to identify the decisions and interventions through which research changes fields, allocates resources, creates classifications, and conditions later possibilities even when knowledge production remains the principal orientation. The method is consequence-sensitive: practical effects are evaluated according to what they do rather than according to whether the project labels itself research.

Section 9.23 already established that research contains decisions about questions, evidence, methods, models, intervention, incomplete knowledge, and normative premises. These decisions can affect participants and institutions. Sampling can create burdens or exclusions. Data collection can expose sensitive relations. Publication can change reputation or bargaining position. A newly introduced category can reorganize a field. Research funding allocates resources among problems and communities. A pilot designed primarily to learn can alter the environment that later research seeks to understand.

The practical dimension also includes non-action. A decision to postpone publication, decline an intervention, omit a population, retain a dataset, or avoid sharing a model can preserve some possibilities while foreclosing others. Research governance in Section 9.17 is partly necessary because epistemically oriented projects already contain such practical decisions.

Definition 9.446 (Embedded application function). *An embedded application function is a practically consequential decision or intervention occurring within research-dominant praxis whose immediate purpose can remain epistemic while its effects al-*

ter relations, resources, classifications, exposure, access, or future options in the field of inquiry.

The presence of embedded application functions does not collapse the praxis distinction. A field experiment, public dataset release, or research classification can remain part of research-dominant praxis when the project is principally organized around resolving epistemic questions. The distinction becomes unstable when the practical consequence itself begins to organize the project more strongly than the epistemic task, as Section 9.23 described through principal-contradiction reassessment.

Proposition 9.447 (Consequence-sensitive research orientation). *Research-dominant orientation does not reduce responsibility for practical effects generated by research decisions; consequential embedded application functions should be governed according to their actual effects while the overall praxis mode remains determined by its principal organizing function.*

This proposition preserves both sides of the distinction. Research can remain research-dominant without claiming practical innocence. Application can remain application-dominant while retaining substantial inquiry. The two modes are configurations with different principal orientations, not sealed institutional worlds.

9.26.7 Transition to Application-Dominant Praxis and Methodology

The immediate transition from Part III is to application-dominant praxis and methodology. Its role is to carry the completed research architecture into a domain where action, intervention, timing, non-action, and responsibility under incomplete knowledge become the principal practical concerns. The objective is to specify which elements travel forward and which elements require transformation when practical closure becomes dominant. The method is transitional: continuity and change across the praxis boundary are stated together.

The research block carries forward evidence, relational and generative models, historical reconstructions, uncertainty profiles, robustness results, scenario structures, negative findings, competing interpretations, governance arrangements, provenance, and reopening conditions. These objects can materially improve application because they prevent practical judgment from beginning from unstructured intuition alone. Yet their function changes when they become connected to action. Evidential uncertainty becomes a component of practical risk. Model error can become distributed harm. A boundary choice can exclude affected actors. A normative premise can determine who bears costs. Delay can itself have consequences.

The next part therefore requires additional architectures: practical situation diagnosis, construction of action spaces, evidence thresholds for action, plural ends, scenario comparison, timing, scale, reversibility, intervention depth, participation, responsibility, justice, monitoring, feedback, repair, withdrawal, and practical closure. Many of these concepts have appeared in research form, but their organizing relation changes when the question becomes what to do while knowledge remains incomplete.

Definition 9.448 (Praxis transition interface). *A praxis transition interface is the documented relation through which research outputs, uncertainties, models, governance*

structures, and reopening conditions are transferred into a phase where consequential practical choice becomes principal, together with the additional normative, institutional, temporal, and responsibility conditions required by that change of function.

The interface can be crossed repeatedly. An application project can return to research-dominant inquiry when a mechanism is poorly understood, a model fails, or a new category problem emerges. A research project can move toward application when a pilot becomes operational or when institutions begin acting on its outputs. The distinction therefore supports phase-sensitive governance rather than a once-for-all classification of projects or organizations.

Proposition 9.449 (Praxis transition by organizing function). *The transition from research-dominant to application-dominant praxis occurs when the organization of consequential action under incomplete knowledge becomes more practically determinative than the stabilization and revision of knowledge itself, even though research functions can continue within the same project or institution.*

Proposition 9.449 establishes the handoff to Part IV. The next chapters can therefore reuse the research architecture without repeating it, while adding the practical disciplines required when evidence and models enter decisions whose consequences cannot be deferred until uncertainty disappears.

9.26.8 Preparation for the Later Return to the Economic Domain

The final task is to position the research block within the larger sequence of the book. Its role is to clarify that the immediate next step is Part IV, while the substantive economic reconstruction begins after research-dominant and application-dominant praxis have both been articulated. The objective is to state why this ordering matters for GRE and what the completed block contributes to the later return to economics. The method is programmatic: the book's next movements are connected without treating their sequence as a hierarchy of importance.

Part V will return to the economic domain with a richer infrastructure than would have been available if substantive economics had followed directly from the foundational chapters. By that point the book will possess an explicit account of how economic knowledge is produced and revised, how methods access relational and generative structures, how complete research projects are designed, and how research outputs participate in decisions and interventions under incomplete knowledge. Substantive concepts can then be developed with both epistemic and practical consequences in view.

This ordering matters especially for GRE because many economic categories become operative as well as descriptive. Ownership classifications allocate rights. Measures of value affect accounting and policy. Labor categories structure eligibility and bargaining. Market definitions influence regulation. Models of risk alter pricing and access. Economic theory can therefore travel rapidly from representation into institutional action. Developing application-dominant praxis before the substantive economic block makes those transitions analytically visible from the beginning.

The research block also prepares later substantive analysis by preserving plurality. A future GRE concept need not be grounded in one privileged method or model. It can

inherit historical, interpretive, quantitative, formal, computational, and practical evidence while retaining the differences among them. When those forms of evidence conflict, the adjudication, sensitivity, robustness, and uncertainty architectures of this chapter remain available. When application changes the object, the reopening and historical re-epistemization architectures remain available as well.

Definition 9.450 (Research-block carry-forward state). The *research-block carry-forward state* is the preserved set of research architectures, evidential lineages, methodological resources, models, uncertainty profiles, governance relations, closure records, and reopening conditions that remains available to application-dominant praxis and to the later substantive development of GRE.

This state marks completion without sealing the block. Later chapters can send corrections backward. A substantive economic concept may reveal that a relational method needs refinement. An intervention can show that a generative model omitted strategic adaptation. A value-conversion analysis can require new forms of measurement. An AI-mediated economic institution can expose governance problems not visible in earlier examples. The research block remains available for revision because its own completion has been defined provisionally.

Proposition 9.451 (Open completion of the research-dominant praxis block). *Completion of the research-dominant praxis block establishes a sufficiently coherent and revisable infrastructure for later practical and substantive inquiry while preserving the possibility that those later inquiries can modify the concepts, methods, models, and standards through which the research block itself was constructed.*

Proposition 9.451 closes Part III in the same spirit in which Section 9.25 closed an individual research cycle. The block is complete because its present role in the book has been fulfilled, while its architecture remains open to re-epistemization. Part IV can now shift the principal practical problem from how warranted knowledge is generated and revised to how consequential action is organized under incomplete knowledge, plural values, risk, irreversibility, and distributed effects. The later return to the economic domain will then inherit both sides of praxis: disciplined inquiry and disciplined action, connected through records that make their mutual transformation visible.

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