

Chapter 17

Knowledge and Epistemic Economy

Epistemic Economy and Chapter Scope

Chapter 17 develops the epistemic-economic dimension of Generative Relational Economics. Chapter 16 established that knowledge, classification, evidential access, attention, orientation, and related epistemic conditions can participate in power and governance. Its closing boundary was deliberately narrow: when epistemic objects, capacities, relations, or infrastructures materially enter access, allocation, accumulation, conversion, value generation, dependency, power, preservation, or institutional reproduction, governance analysis alone no longer characterizes the economic organization of the epistemic field. The present chapter takes that field as its substantive object. It asks how knowledge and the conditions of knowing are produced, accessed, accumulated, withheld, translated, verified, preserved, governed, and transformed, and how those processes alter later economic capacities and possibilities.

The term *epistemic economy* is used here in a bounded analytical sense. It refers to the economic organization of epistemic objects, capacities, relations, processes, and infrastructures insofar as they participate materially in the generation and distribution of economic possibility. The relevant objects can include data, records, concepts, models, classifications, explanations, questions, expertise, methods, archives, standards, languages, computational resources, verification practices, and institutionalized bodies of knowledge. The relevant capacities can include learning, interpretation, inquiry, verification, translation, judgment, orientation, memory, and the ability to form or revise questions. The relevant relations include teaching, collaboration, testimony, accreditation, publication, classification, platform mediation, human–AI interaction, and relations among institutions that determine which knowledge becomes visible, credible, preservable, or actionable. The chapter therefore treats epistemic economy as broader than a market in information and narrower than a complete theory of knowledge.

This formulation preserves several distinctions established earlier in the book. *Information* can be abundant while usable knowledge remains scarce. Possession of a record differs from the capacity to interpret or verify it. Formal access differs from practical epistemic access when language, expertise, compute, time, institutional

standing, or interpretive resources remain unavailable. Knowledge can function as a resource in one inquiry, as a capability in another, as a relation or infrastructure in another, and as a condition of later generation across several of these roles. These descriptions can coexist without implying that knowledge is a homogeneous substance. The economic question concerns which aspect is causally and institutionally relevant in the specified setting.

The chapter also resists reducing knowledge to ownership. Property and control can matter greatly, especially where exclusion, licensing, secrecy, intellectual property, platform access, archives, or proprietary infrastructure condition use. Yet many epistemic objects are non-rival in some uses, socially produced, historically accumulated, difficult to assign to a single origin, dependent on shared languages and institutions, or transformed through participation by multiple knowers. Knowledge can be controlled without being exclusively owned, accessed without being controlled, reproduced without materially depleting the original representation, and lost despite nominal legal ownership when the interpretive or preservation infrastructure decays. Section 17.1 therefore begins with a plural economic characterization of knowledge and makes the limits of ownership language explicit.

A second objective is to analyze the changing relation between epistemic scarcity and abundance. Scarcity can arise through restricted access, expertise requirements, education, institutional position, language, technical infrastructure, exclusion, or rent-producing control. At the same time, digital networks and generative systems can produce extreme abundance of documents, claims, summaries, images, code, explanations, and candidate answers. Abundance at one layer can generate scarcity elsewhere. Verification, attention, orientation, provenance, trust, judgment, and the capacity to identify questions worth pursuing can become more consequential precisely when symbolic production becomes cheap. Sections 17.2–17.4 therefore examine knowledge scarcity, epistemic abundance, and attention as related but non-identical economic problems.

The chapter gives special attention to epistemic orientation because knowing does not begin only after a well-formed question has already been supplied. Encounter, salience, curiosity, wonder, aesthetic judgment, research taste, and long-horizon inquiry can influence which problems enter sustained attention and which possible lines of inquiry remain unrealized. These phenomena are economically consequential when time, funding, educational opportunity, prestige, institutional evaluation, platform visibility, or immediate utility pressures condition their development. Sections 17.5 and 17.6 examine question formation and aesthetic-epistemic orientation without treating curiosity or beauty as universal metrics of truth or social value. Their role is to identify generative conditions of inquiry whose economic organization can alter later knowledge trajectories.

A third objective is to connect epistemic difference with economic asymmetry while preserving the distinctions stabilized in Chapter 16. A knowledge difference does not by itself constitute power. Interpretive, verification, computational, and institutional asymmetries become power-relevant when they are converted through mechanisms that materially condition another position's feasible action, access, recognition, dependency, or future options. Persistent epistemic asymmetries can also be reproduced through education, classification, infrastructure, credentials,

archives, language, proprietary systems, or differential access to verification. Section 17.7 develops these forms of asymmetry, while Section 17.8 examines knowledge capital as historically accumulated epistemic capacity and infrastructure. The latter concept is treated carefully: accumulation, ownership, control, access, infrastructure, rent, and intergenerational advantage remain distinct dimensions rather than interchangeable meanings of capital.

The chapter then examines extraction and institutionalization. Epistemic systems can draw on knowledge, attention, creative labor, data, interpretation, and unpaid or weakly compensated generative activity. Such processes can support shared learning and collective production, yet they can also produce asymmetric capture, dependency, depletion, or platform-mediated extraction under specified arrangements. Section 17.9 develops generative exploitation in epistemic systems without presuming that every contribution relation is exploitative. Sections 17.10 and 17.11 then analyze the institutions and infrastructures through which epistemic activity is organized: schools, universities, research institutes, libraries, archives, publishers, platforms, funding institutions, standards, data, compute, networks, languages, verification systems, and preservation systems. These structures can simultaneously enable knowledge generation and condition access, visibility, authority, dependency, and future reanalysis.

Normative evaluation enters through epistemic justice in Section 17.12. The chapter focuses on visibility, voice, classification, evidential resources, interpretive authority, contestability, preservation, and future re-recognizability. These dimensions connect epistemic justice with the relational, generative, historical, and participatory justice architectures of Chapter 16 while retaining their specific epistemic object. Unequal expertise or differentiated authority does not automatically establish injustice; some epistemic roles require specialization and asymmetrical competence. The justice question concerns how such differences are formed, recognized, governed, contested, translated into consequential decisions, and reproduced over time, including whose experiences and records remain available for future interpretation.

Preservation therefore receives separate treatment within the epistemic economy. Records and knowledge processes extend beyond production and access. Records can disappear, provenance can be severed, negative results can remain unpublished, historical context can be lost, and later categories can transform how earlier evidence is interpreted. Section 17.13 therefore develops knowledge preservation and re-epistemization as an intertemporal economic problem. Preservation consumes resources and can itself create privacy, security, stewardship, and selection burdens, while failure to preserve can eliminate future verification, reinterpretation, accountability, and learning. The relevant problem is therefore selective and governed preservation rather than indiscriminate retention.

A further objective is to preserve the relational character of knowing. Learning can transform the knower, alter relations among persons and objects, and change later capacities to perceive, question, interpret, or act. Human-human, human-object, and human-AI learning relations can therefore be economically consequential even where their value cannot be reduced to immediate instrumental output. Section 17.14 examines knowing as relational participation and as transformation of future possibility. This analysis also protects a space for inquiry whose

significance is exploratory, aesthetic, cultural, existential, or only retrospectively recognizable. GRE can analyze the economic conditions under which such inquiry becomes possible without requiring that its value be justified by a predetermined productivity measure.

The chapter closes its substantive economic analysis by examining knowledge commons and open epistemic systems in Section 17.15. Openness can broaden access, enable reuse, support verification, and distribute generative capacity, while open systems can also create maintenance burdens, attribution problems, uncompensated extraction, enclosure at downstream layers, or dependency on concentrated infrastructure. Commons governance therefore concerns shared infrastructure, attribution, reciprocity, sustainability, boundaries, and plural knowledge systems as well as access itself. Openness and enclosure are treated as dimensions of institutional design whose consequences depend on the object, infrastructure, governance regime, and positions affected.

Artificial intelligence appears throughout the chapter where it changes epistemic-economic conditions, especially abundance, verification, attention, infrastructure, asymmetry, labor, and human–AI learning. The chapter nevertheless preserves a boundary with Chapter 18. Section 17.16 examines artificial intelligence within the epistemic economy only far enough to identify machine knowledge generation, symbolic abundance, capability concentration, human–AI asymmetry, and epistemic dependence as conditions requiring a more specialized analysis. Chapter 18 then takes radical capability asymmetry as its primary object. This separation prevents the present chapter from making the epistemic economy synonymous with the AI economy while still recognizing that contemporary AI materially changes the scale, speed, cost structure, and institutional distribution of epistemic production.

Methodologically, the chapter remains plural. Historical and institutional analysis can reconstruct how universities, archives, professional standards, intellectual property regimes, platforms, and evaluation systems formed. Qualitative inquiry can examine learning, classification, interpretation, exclusion, and epistemic dependence. Quantitative and computational methods can study attention allocation, citation networks, access distributions, platform visibility, knowledge diffusion, verification burdens, and infrastructure concentration. Formal models can represent selected processes when their objects and assumptions are explicitly defined. No one method is presumed to exhaust the epistemic economy, because the relevant phenomena include material infrastructure, institutional rules, symbolic systems, embodied capacities, relations of authority, historical traces, and context-dependent judgment.

The internal sequence follows the economic lifecycle of epistemic possibility. Section 17.1 establishes knowledge as a plural economic object. Sections 17.2–17.4 examine scarcity, abundance, and attention. Sections 17.5 and 17.6 examine question formation and epistemic orientation. Sections 17.7–17.9 develop epistemic asymmetry, knowledge capital, and generative exploitation. Sections 17.10 and 17.11 turn to knowledge institutions and epistemic infrastructure. Sections 17.12 and 17.13 develop epistemic justice, preservation, and re-epistemization. Sections 17.14 and 17.15 examine knowing as relational participation and the governance of knowledge commons. Section 17.16 closes the chapter with the bounded interface to artificial intelligence and radical capability asymmetry.

The chapter's structural contribution is therefore an economic account of the conditions under which knowing becomes possible, consequential, preservable, and unevenly distributed. Knowledge can expand without eliminating epistemic scarcity; abundance can increase the value of verification and orientation; institutions that preserve knowledge can also govern access and recognition; openness can distribute generative capacity while exposing contributors to new forms of capture; and the capacity to ask, interpret, verify, remember, and revise can shape future economic possibility as materially as more familiar resources. The epistemic economy places these relations within GRE without reducing knowledge to commodity, property, information quantity, or immediate productivity. It thereby supplies the intermediate architecture required before Part VI turns to artificial intelligence and radical capability asymmetry.

17.1 Knowledge as Economic Object

The role of this section is to establish the basic analytical object of Chapter 17. The chapter cannot examine knowledge scarcity, epistemic abundance, attention, knowledge capital, epistemic institutions, or knowledge commons coherently unless the economic status of knowledge is first specified. The objective is therefore to identify the principal ways in which knowledge can become economically consequential while preserving distinctions among content, capacity, relation, infrastructure, power, and generative condition. The discussion proceeds through eight roles: knowledge as resource, capacity, relation, infrastructure, power, generative condition, an object only partially described by ownership language, and an epistemic event capable of changing later economic possibilities. The method is analytical and institutional. It does not attempt to settle a general philosophical definition of knowledge; it asks when and through which mechanisms epistemically warranted content, know-how, models, classifications, records, or recognized expertise enter economic processes in consequential ways.

The expression *economic object* is used here in the broad GRE sense. An object becomes economically relevant when its production, absence, access, allocation, preservation, control, interpretation, or transformation materially conditions economic relations, capacities, processes, values, or future possibilities. Knowledge can satisfy this condition without becoming a conventional commodity. A theorem, production routine, clinical protocol, navigational skill, engineering model, local ecological understanding, archive, statistical classification, or recognized body of expertise can enter economic life through very different institutional pathways. Treating all of them as a homogeneous stock would obscure the mechanisms through which they become consequential.

Definition 17.1 (Knowledge-economic profile). A *knowledge-economic profile* is a scoped representation of an epistemically organized content or capacity together with the positions that can access, interpret, verify, apply, transmit, modify, preserve, authorize, or contest it; the infrastructures and relations supporting those functions; and the economic consequences through which the knowledge configuration becomes consequential in a specified field.

Table 17.1: Analytical roles of knowledge as an economic object in GRE.

Role	Primary economic function	Principal analytical distinction
Resource	Usable epistemic input into production, coordination, diagnosis, design, or decision	Availability and possession remain distinct from practical usability
Capacity	Ability to interpret, generate, verify, apply, revise, or teach knowledge	Content possession remains distinct from competence and conversion capacity
Relation	Knowledge constituted, recognized, transmitted, or made actionable through relations among positions	Individual holding remains distinct from relational conditions of uptake and trust
Infrastructure	Stabilized epistemic conditions supporting repeated coordination across many transactions or actors	A specific knowledge item remains distinct from the infrastructure that makes epistemic activity reliable
Power	Knowledge position that conditions another position's access, action, standing, burden, or feasible trajectory	Epistemic difference remains distinct from mechanism-mediated economic power
Generative condition	Knowledge configuration that changes what later actions, capacities, relations, or inquiries can be generated	Immediate informational value remains distinct from effects on future possibility
Ownership limits	Legal and institutional organization of access, use, exclusion, attribution, control, and stewardship	Ownership remains distinct from access, competence, control, authorship, and practical dependence
Epistemic event	Change in an epistemic state whose uptake can alter later economic conditions	Revision of representation remains distinct from transformation of the represented field

Definition 17.1 is intentionally relational. The profile does not presume that knowledge is reducible to a detachable item possessed by one bearer. It can include codified content, embodied competence, organizational routines, shared standards, interpretive practices, and historically accumulated records. The profile is also purpose-specific. A dataset usable for one task may be practically inaccessible for another if the relevant interpretive capacity, provenance, permissions, or computing infrastructure are absent. Likewise, expertise recognized in one institutional domain may carry little authority in another.

Table 17.1 summarizes the eight roles developed in this section. The rows should be read as analytically distinguishable modes that can coexist within the same empirical case.

Proposition 17.2 (Plural-role condition). *Within a specified economic field, the same knowledge configuration can occupy several economic roles simultaneously, while evidence for one role does not by itself establish the others.*

Proposition 17.2 provides the section's organizing discipline. A technical standard can be a resource for designers, an infrastructure for interoperability, a source of authority for certification, and a generative condition for future products. Those roles can reinforce one another, yet they require different evidence. The existence of the standard does not establish that a particular actor can use it effectively; recognized

expertise does not establish power over another position; open publication does not establish practical access; and legal control does not establish interpretive capacity.

17.1.1 Knowledge as Resource

Knowledge can function as a resource when it enters a specified economic activity as a usable epistemic input. Production plans, scientific findings, market information, engineering tolerances, legal interpretations, medical protocols, agricultural knowledge, software documentation, and accumulated practical know-how can reduce search costs, improve coordination, support diagnosis, reveal alternatives, or change the feasible use of other resources. Hayek's analysis of dispersed knowledge remains a classic statement of the coordination problem created when relevant knowledge is distributed among different persons and cannot be fully centralized in advance (Hayek 1945). The GRE extension is to treat the economic significance of such knowledge as dependent on the relations and infrastructures through which it becomes usable.

Knowledge as resource differs from many material resources in several respects. Use by one position does not necessarily consume the underlying content. Copying can be inexpensive for some codified forms, while tacit, embodied, context-sensitive, confidential, or infrastructure-dependent knowledge can remain costly to reproduce or transfer. Arrow's analysis of invention and information emphasizes uncertainty and appropriation problems that distinguish informational production from ordinary commodity production (Arrow 1962). These differences help explain why an economic analysis centered only on physical scarcity can misdescribe knowledge-intensive activity. They do not establish that knowledge is generally abundant or universally non-rival. Verification, interpretation, education, secrecy, legal permissions, computing resources, language, institutional standing, and attention can all remain scarce even when symbolic content is easy to copy.

The resource interpretation should therefore identify the unit and use context. A published formula can be globally visible yet unusable to a firm lacking the engineering competence required to implement it. A public dataset can be technically accessible while its documentation, scale, licensing conditions, or computing requirements make practical use difficult. Local knowledge can be highly consequential for one ecological or social setting while losing reliability when transferred without its contextual relations. The economically relevant resource is therefore more precisely the usable knowledge configuration than the mere presence of symbolic content.

Knowledge can also complement other resources. Equipment without operating knowledge can remain idle. Capital without knowledge of local conditions can be misallocated. Data without a model or interpretive framework can remain weakly informative. Conversely, knowledge can increase the productivity or flexibility of existing material resources by changing how they are combined, maintained, repaired, or redirected. Such complementarity is one reason the economic value of knowledge cannot be inferred from its isolated exchange price. A low-cost or freely available body of knowledge can have high downstream consequence when combined with scarce capacities or infrastructures.

Proposition 17.3 (Availability–usability distinction). *The availability of epistemic con-*

tent supports a claim of knowledge-resource access only when the relevant position can practically identify, reach, interpret, and apply that content within the specified economic activity.

Proposition 17.3 does not require that every user possess the same competence. Translation, professional services, software interfaces, education, or institutional intermediaries can convert available content into usable resource. The proposition instead prevents nominal availability from standing in for practical use. This distinction becomes central in Section 17.2, where scarcity shifts from the existence of knowledge toward access, expertise, institutional position, language, technical capacity, and exclusion.

17.1.2 Knowledge as Capacity

Knowledge also functions as capacity. The relevant object is then an ability to perceive, interpret, diagnose, calculate, verify, design, explain, teach, maintain, or revise rather than a body of content considered independently of a knower or institution. Education and training have long been analyzed economically as investments in productive skill and knowledge (Becker 1964). GRE retains the importance of acquired competence while widening the unit of analysis beyond individual productivity. Epistemic capacity can be embodied in persons, distributed across teams, stabilized in organizations, supported by software and instruments, or produced through relations among specialized positions.

The capacity interpretation matters because possession of content and ability to use it can diverge sharply. Access to a manual does not establish the capacity to repair the machine. Availability of a statistical model does not establish competence to evaluate its assumptions. Possession of a legal database does not establish the interpretive judgment required for representation. A laboratory may hold extensive data while lacking the staff, instrumentation, or methodological diversity needed to validate a result. The economic object therefore includes the conversion conditions through which epistemic content becomes effective capability.

Capacity can also be collective. A complex engineering project can require complementary expertise in materials, software, regulation, safety, finance, and local operations. No single participant possesses the complete relevant knowledge. The capability exists through sufficiently reliable coordination among partially specialized positions. This collective form connects knowledge to the relational architecture developed throughout GRE: interface quality, trust, standards, communication, authority, and institutional continuity can be constitutive of epistemic capacity rather than external additions to it.

Knowledge capacity has a temporal structure. Competence can depreciate when practice stops, tools change, institutional memory disappears, or standards evolve. It can also accumulate through repeated use, apprenticeship, documentation, reflection, and participation in communities of practice. Some capacities remain latent until a triggering condition makes them relevant. Others become obsolete when the environment changes. A static inventory of credentials or documents therefore provides only a partial representation of epistemic capacity.

Definition 17.4 (Epistemic economic capacity). *An epistemic economic capacity is the*

practically supported ability of a person, collective, organization, institution, or relational configuration to generate, interpret, verify, apply, transmit, preserve, or revise knowledge in ways that can materially affect a specified economic process or possibility.

Definition 17.4 is broader than individual skill and narrower than general intelligence or potential. It requires a specified function and practical support conditions. A capacity can depend on tools, time, language, institutional authority, access to records, trusted collaborators, or legal permission. These dependencies make epistemic capacity a suitable object for later analysis of scarcity, infrastructure, justice, and asymmetry.

Proposition 17.5 (Content–capacity non-equivalence). *Possession or access to epistemic content does not by itself establish the capacity to interpret, verify, apply, transmit, or revise that content in a specified economic setting.*

The proposition also works in the opposite direction. A skilled practitioner can possess substantial embodied capacity without being able to articulate all relevant knowledge as detached propositions or documents. The chapter therefore avoids using information quantity as a universal proxy for epistemic capability.

17.1.3 Knowledge as Relation

Knowledge can be relational in at least three economic senses. First, its production can depend on relations among observers, teachers, collaborators, institutions, instruments, objects, and inherited records. Second, its practical recognition can depend on relations of trust, authority, certification, language, and institutional standing. Third, its meaning and applicability can depend on the relational context in which concepts, classifications, measurements, or procedures are used. The relational interpretation therefore concerns the conditions under which knowledge is generated, recognized, communicated, and made consequential.

This interpretation does not imply that every true claim is socially constructed or that epistemic validity is reducible to institutional recognition. The narrower point is economic: whether knowledge can enter action often depends on relations that connect an epistemic position to other positions. A scientist may possess a well-supported result that has little economic consequence until it enters a standards process, procurement decision, clinical guideline, engineering design, investment decision, or public institution. A worker may hold detailed process knowledge while lacking a recognized channel through which that knowledge can alter organizational practice. A community may possess locally grounded knowledge that remains excluded when the governing institution recognizes only a narrower evidential form.

Recognition relations can therefore matter economically without determining truth. Credentials, professional status, peer review, certification, organizational role, and reputation can function as institutional shortcuts for deciding whose claims receive attention or authority. Such mechanisms can reduce coordination costs and support specialization. They can also create exclusion, dependency, or error when recognized status becomes detached from current competence or when alternative sources lack routes to institutional uptake. Fricker's account of epistemic injustice provides one important normative precedent for examining credibility and interpre-

tive exclusion (Fricker 2007); later sections will distinguish those justice questions from the descriptive relational architecture developed here.

Relational knowledge also includes the knowing of relations themselves. Supply-chain knowledge, network position, institutional procedure, contractual dependency, social trust, and historical provenance can be economically valuable because they represent how positions are connected rather than properties of isolated entities. Much practical expertise consists in recognizing which relation is consequential, which interface is failing, which actor can authorize change, or which historical dependency constrains the apparent choice set. GRE therefore treats relational knowledge as compatible with, but broader than, an inventory of facts about separate objects.

The economic importance of relation becomes especially visible in transmission. Communication requires more than a sender and a message. Shared language, conventions, timing, trust, interpretive background, attention, and opportunities for correction can condition whether a transmitted representation becomes knowledge for the receiving position. Knowledge transfer can therefore fail even when information transfer succeeds. This distinction will recur in the chapter's treatment of education, epistemic infrastructure, relational knowing, and open systems.

Proposition 17.6 (Relational uptake condition). *Where economic consequence depends on another position recognizing, interpreting, or acting upon a knowledge claim, the relevant knowledge-economic profile includes the relations governing uptake as well as the underlying epistemic content.*

Proposition 17.6 makes institutional pathways visible without equating recognition with validity. It also clarifies why a redistribution of information can leave epistemic inequality largely unchanged when the relations required for interpretation, standing, or consequential uptake remain concentrated.

17.1.4 Knowledge as Infrastructure

Knowledge acquires an infrastructural role when stabilized epistemic arrangements support repeated coordination across many activities and positions. Classification systems, accounting conventions, technical standards, statistical series, maps, registries, archives, libraries, dictionaries, scientific taxonomies, reference models, legal records, and shared documentation can become background conditions through which later action is made possible. Their economic significance lies partly in repeated use: once widely relied upon, they can reduce coordination costs, preserve memory, enable interoperability, and provide common reference points across transactions or institutions.

The infrastructure role differs from the resource role. A particular engineering report can serve as a resource for one project. A durable measurement standard can support thousands of projects by stabilizing the terms in which measurements are produced and compared. A dataset can be a resource; the data architecture, identifiers, metadata standards, verification procedures, and preservation systems that make successive datasets interoperable constitute a broader infrastructural layer. Bowker and Star's analysis of classification and standards demonstrates how such systems can become embedded infrastructures that organize visibility and interaction

(Bowker and Star 1999). Porter's history of quantitative objectivity likewise shows how standardized numerical practices can acquire institutional authority far beyond individual calculations (Porter 1995).

Epistemic infrastructure can be enabling and constraining at the same time. Stable categories make comparison possible, yet they can exclude cases that fit poorly. Common standards enable interoperability, yet switching costs can stabilize obsolete designs. Archives preserve evidence, yet retention and selection policies shape future visibility. Shared languages widen communication within a field while creating barriers for those outside its linguistic conventions. Infrastructure therefore has a generative and historical character: it changes the cost and possibility of later knowing while carrying earlier classifications and institutional decisions forward.

Infrastructure also distributes dependency. A widely shared reference system can reduce bilateral coordination burdens because participants need not renegotiate every epistemic convention. At the same time, concentration of control over the infrastructure can create new dependencies. If one platform controls identity, provenance, search, citation, certification, or access to a crucial knowledge repository, broad usability can coexist with concentrated governance capacity. The economic analysis must therefore distinguish the distribution of use from the distribution of authority over maintenance, revision, and access.

Knowledge commons provide a further institutional form. Hess and Ostrom show that knowledge can be studied through commons analysis while retaining differences between knowledge resources and natural-resource common-pool systems (Hess and Ostrom 2007). Shared repositories, open standards, collaborative databases, and public libraries can distribute epistemic infrastructure while still requiring governance of contribution, preservation, attribution, quality, access, and sustainability. Section 17.15 will return to these issues in detail.

Definition 17.7 (Epistemic infrastructural role). A knowledge configuration has an *epistemic infrastructural role* when its comparatively stabilized use supports repeated generation, interpretation, verification, transmission, coordination, or preservation across a wider field of economic activity than the immediate task for which any single knowledge item is used.

The definition is functional rather than ontological. The same object can shift between resource and infrastructure depending on scale and institutional embedding. A technical protocol used once is a task-specific resource; once it becomes a common interface relied upon across many organizations, its infrastructural role becomes analytically significant.

17.1.5 Knowledge as Power

Knowledge can become power when an epistemic position participates in a mechanism that materially conditions another position's feasible action, access, standing, burden, or future trajectory. Chapter 16 developed this mechanism-based interpretation in its analysis of economic epistemic power. Section 403 retains that boundary. A difference in knowledge, expertise, prediction, or verification capacity can produce advantage without constituting power over a particular counterpart. The stronger power claim requires a consequential relational mechanism.

Several mechanisms are common. Exclusive knowledge can support bargaining leverage where another party cannot verify quality or risk. Recognized expertise can carry authority over admission, licensing, diagnosis, certification, or compliance. Control over classifications can determine eligibility, creditworthiness, risk status, or institutional visibility. Proprietary data or models can condition the ability of others to compete, appeal, or understand decisions. Secrecy can preserve strategic advantage. Predictive capacity can permit earlier action when timing materially affects later options. The knowledge-power relation therefore depends on how epistemic difference enters an economic interface.

The same knowledge position can also support legitimate specialization. Medical expertise, engineering judgment, auditing competence, scientific assessment, and professional certification can improve collective decisions when their authority is appropriately scoped, accountable, contestable, and connected to relevant evidence. Power analysis should therefore identify the conditioning mechanism before normative evaluation begins. The existence of epistemic power does not settle whether the relation is justified, unjust, beneficial, necessary, or harmful.

Knowledge power can be infrastructural rather than personal. Standards bodies, rating systems, databases, statistical agencies, search systems, credentialing institutions, and classification infrastructures can shape what becomes visible, comparable, admissible, or actionable. In such cases, power may be distributed across technical rules, institutional mandates, software, professional routines, and recognized interpretive communities. This distribution complicates simple accounts of ownership or command because no single actor may possess complete control while the infrastructure still conditions many positions.

Power can also arise through withholding. Strategic concealment, inaccessible documentation, opaque models, delayed disclosure, or non-portable records can increase dependency where another position requires the knowledge to exercise rights, change providers, verify performance, or coordinate alternatives. Conversely, transparency alone does not eliminate epistemic power if interpretation, verification, attention, or institutional standing remain concentrated. The economic object is therefore the consequential knowledge relation, including the capacities and institutions that convert epistemic difference into practical effect.

Proposition 17.8 (Epistemic-difference conversion condition). *An epistemic difference supports a claim of economic power only where an identifiable mechanism converts that difference into material conditioning of another position's access, action, standing, burden, contestability, or feasible trajectory.*

Proposition 17.8 preserves continuity with Chapter 16 while preparing Section 17.7. The later section will analyze several forms of epistemic asymmetry and the conditions under which they persist. The present subsection establishes only the economic role through which knowledge can become power.

17.1.6 Knowledge as Generative Condition

Knowledge can function as a generative condition when it changes the space of later actions, relations, capacities, questions, designs, or institutional possibilities. This role is broader than immediate productivity. A scientific result can open a research

programme. A legal interpretation can make a new organizational form feasible. A technical standard can enable an ecosystem of compatible products. Historical knowledge can reveal previously invisible dependencies. Education can alter the questions a learner is capable of asking. A shared model can make coordination possible among actors who could not previously align their expectations.

The generative role therefore concerns what later becomes reachable. Knowledge can enlarge future possibility by revealing options, reducing uncertainty, enabling combination, or creating new capabilities. It can also narrow future possibility when a classification becomes entrenched, when an incorrect model redirects investment, or when a dominant paradigm crowds out alternative questions. Generative consequence is thus direction-sensitive and historically contingent. More knowledge in one dimension does not automatically increase every relevant possibility.

Knowledge can generate further knowledge. Methods, instruments, theories, archives, and standards can create conditions for observations and questions that were previously unavailable. A new measurement technique can make a phenomenon observable; a new archive can make historical comparison possible; a conceptual distinction can permit a later theory; a computational tool can expand the feasible search space. This recursive structure differentiates knowledge from an input that disappears after one use. Some epistemic outputs become part of the machinery through which later epistemic production occurs.

The recursive effect can also cross domains. Knowledge generated in science can alter engineering capacity; engineering can create new instruments for science; legal knowledge can change institutional access; institutional change can alter data generation; new data can revise economic models. The generative path is therefore frequently relational and multistage. Attribution of effect requires tracing the relevant pathway rather than assuming that all later changes derive from the earlier knowledge event.

Definition 17.9 (Generative epistemic condition). *A generative epistemic condition is a knowledge configuration whose availability, interpretation, institutional uptake, or practical application materially changes the set or accessibility of later actions, relations, capacities, inquiries, or economic trajectories within a specified field and horizon.*

The definition requires a specified field and horizon because generative effects can be local, delayed, or path-dependent. A discovery can generate many scientific possibilities while having little immediate economic application. A production routine can improve one organization's capacity while increasing dependence on a proprietary platform. A public standard can widen interoperability while reducing diversity in competing technical approaches. Generative analysis therefore complements, rather than replaces, valuation and justice analysis.

Proposition 17.10 (Epistemic generativity recursion). *Where knowledge materially changes the capacities or infrastructures through which later knowledge is produced, the resulting epistemic process can become recursively generative across successive historical stages.*

Proposition 17.10 motivates later analysis of knowledge capital, institutions, infrastructure, preservation, and commons. Recursive generativity can support cumula-

tive learning, yet it can also reproduce asymmetry when the capacities for generating later knowledge remain concentrated.

17.1.7 Limits of Ownership Language

Ownership language captures important parts of the epistemic economy, especially where law grants exclusion, licensing, transfer, or control rights over specified expressions, data arrangements, inventions, trade secrets, or infrastructures. It nevertheless provides an incomplete description of many knowledge relations. A person can own a book without understanding it, understand a method without owning its formal expression, possess a trade secret without controlling the wider scientific field, contribute to a body of knowledge without holding exclusion rights, or depend on a platform whose operator owns neither every contribution nor every item of knowledge circulating through it.

The analytical problem is therefore multidimensional. At least seven positions can diverge: possession of a representation, practical access, competence to use it, authority to modify or certify it, legal exclusion rights, attribution or authorship, and stewardship obligations. A further distinction concerns infrastructure control. An actor may lack ownership of the underlying knowledge while controlling the repository, search system, compute environment, identity layer, or standard through which others reach it. Conversely, open licensing can remove one form of exclusion while leaving language, equipment, compute, verification, or attention as effective barriers.

Arrow's analysis of invention already identified difficulties in appropriating informational returns and the unusual relation between information disclosure and market exchange (Arrow 1962). Commons scholarship extends the institutional vocabulary by treating knowledge as a resource whose access, preservation, enclosure, contribution, and governance can be organized in forms that do not map cleanly onto a simple privately owned versus unowned binary (Hess and Ostrom 2007). GRE uses these precedents to preserve analytical space for differentiated rights, capacities, and dependencies.

The limits of ownership language are also visible in collective and cumulative knowledge. Scientific results can depend on prior literature, shared instruments, public funding, datasets, standards, peer criticism, and institutional memory. Organizational routines can emerge from contributions distributed across many workers and generations. Languages and classification systems are maintained through collective use. Local and Indigenous knowledge can be embedded in communities, practices, places, and obligations that are poorly represented by an individualized property metaphor. The appropriate institutional analysis can therefore require attribution, consent, stewardship, access, reciprocity, confidentiality, or governance mechanisms in addition to, or in some cases in place of, ownership claims.

This broader treatment does not deny property rights or intellectual-property institutions. It asks what those institutions actually organize. Exclusion rights can affect investment, disclosure, bargaining, access, diffusion, and appropriation. Licensing can expand use while preserving specified controls. Trade secrecy can protect commercial knowledge while reducing external verifiability. Public-domain status can widen legal access while leaving practical use dependent on complementary infras-

tructure. Each mechanism should therefore be analyzed through its concrete effects rather than treated as a complete description of the epistemic relation.

Proposition 17.11 (Ownership-scope condition). *Ownership language provides an adequate representation of an epistemic-economic relation only to the extent that the relevant economic consequences are materially organized by the rights and controls captured by that ownership relation; access, competence, attribution, stewardship, infrastructure, and dependency require separate representation where they diverge.*

Proposition 17.11 prepares the later analysis of knowledge capital and knowledge commons. It also prevents the chapter from using “knowledge ownership” as shorthand for every form of epistemic control.

17.1.8 Knowledge as Epistemic Event and Generative Condition

The final role places knowledge within the event architecture developed earlier in GRE. An epistemic state can change when a position observes, learns, infers, measures, receives testimony, encounters a record, verifies a claim, revises a model, or recognizes an earlier error. Such a change can remain internal to representation, or it can enter the practical field through communication, authorization, expectation, coordination, investment, classification, or another uptake mechanism. The economic significance of knowledge therefore depends partly on whether and how an epistemic event is converted into practical consequence.

A new forecast illustrates the distinction. The forecast can first change an analyst’s representation of future conditions. If it remains private and unused, the economic field may be unchanged apart from the analyst’s internal state. If the forecast is communicated to a central bank, insurer, firm, household, or public agency and alters decisions, it becomes part of the causal history of the field being forecast. The epistemic event then has both representational and practical dimensions. Similar recursion occurs when ratings affect financing costs, scientific warnings alter regulation, performance metrics alter behavior, or classifications change eligibility.

This performative possibility should not be generalized automatically. Many observations do not materially transform the observed system. Some are too weak, too private, too delayed, or too institutionally disconnected to generate practical effects. Others are explicitly designed to minimize interference. The analytical task is to identify the uptake pathway and distinguish a change in what is believed from a change in what becomes practically accessible or likely.

Epistemic events can also create generative conditions for later inquiry. Discovering an anomaly can generate a new question; publishing a method can create a community of users; preserving a negative result can prevent repeated dead ends; recognizing a classification failure can motivate new categories; exposing uncertainty can redirect monitoring and research. In each case the knowledge event changes the conditions under which later epistemic events become possible. The event and condition roles are therefore temporally connected.

Definition 17.12 (Epistemic-economic event). *An epistemic-economic event is an epistemic change whose uptake, preservation, communication, authorization, or practical use materially alters an economic relation, process, capacity, value, constraint,*

allocation, or future possibility within a specified field.

Definition 17.12 does not classify the epistemic event as true, beneficial, legitimate, or just. Incorrect beliefs, misleading classifications, and poorly grounded forecasts can also produce economic consequences. Their epistemic quality and their causal efficacy are separate analytical questions.

Proposition 17.13 (Event–condition recursion). *Where an epistemic-economic event changes the capacities, relations, infrastructures, classifications, or incentives through which later knowledge is generated or received, the event becomes part of the generative epistemic conditions of subsequent economic history.*

Proposition 17.13 completes the section’s plural-role architecture. Knowledge can enter economic analysis as resource, capacity, relation, infrastructure, power, generative condition, institutionally governed object, and historically consequential event. These roles can overlap, but each requires its own evidence and mechanism. The next section therefore turns to scarcity. Once knowledge is treated as a plural economic object, scarcity can no longer be represented simply as the absence of information. Access, expertise, education, institutional position, language, technical capacity, exclusion, and rent can each determine which epistemic objects become practically available to whom.

17.2 Knowledge Scarcity

The role of this section is to specify what scarcity means once knowledge has been established as a plural economic object rather than a homogeneous stock. Section 17.1 showed that knowledge can function as resource, capacity, relation, infrastructure, power, generative condition, institutionally governed object, and epistemic-economic event. The objective here is to identify the principal mechanisms through which economically relevant knowledge can remain scarce even when symbolic content or codified information is widely available. The discussion proceeds through access, expertise, education, institutional position, linguistic access, technical access, epistemic exclusion, and knowledge rents. The method is relational and mechanism-specific: scarcity is represented with respect to a specified epistemic object or function, a position seeking to use it, a field of complementary conditions, and a temporal horizon.

Knowledge scarcity therefore does not require a small total stock of information. A technical manual can be publicly downloadable while practical competence remains scarce. A scientific article can be open access while the data, equipment, language, time, or interpretive expertise required for serious use remain concentrated. A professional field can contain many qualified people while recognized authority to certify, diagnose, authorize, or allocate remains scarce. A translation can widen symbolic access while tacit context or institutional vocabulary remains difficult to transfer. Scarcity can consequently reside in content, access, interpretive capacity, recognition, infrastructure, or the institutional pathways through which knowledge becomes actionable.

Definition 17.14 (Knowledge-scarcity profile). *A knowledge-scarcity profile is a scoped representation of the epistemic objects or functions that are practically*

Table 17.2: Dimensions of knowledge scarcity in substantive GRE analysis.

Dimension	Primary scarcity object	Characteristic analytical question
Access	Practical reachability of epistemic objects and use conditions	Which positions can obtain, inspect, retain, verify, and lawfully use the relevant knowledge?
Expertise	Interpretive, verificatory, applicative, and generative competence	Which capacities are required to convert available content into warranted understanding or practical action?
Education	Organized pathways of epistemic-capacity formation	Which positions can enter, persist in, and benefit from learning relations that generate later competence?
Institutional position	Membership, standing, authorization, and recognized role	Which knowledge becomes reachable or actionable only from particular institutional positions?
Linguistic access	Capacity to receive, interpret, and express knowledge across linguistic interfaces	Which meanings, categories, and opportunities remain inaccessible or distorted across language conditions?
Technical access	Hardware, software, compute, instruments, standards, networks, and authentication	Which technical complements condition whether nominally available knowledge can be generated or used?
Epistemic exclusion	Selective blockage of epistemic access, recognition, participation, or contribution	Which relational or institutional mechanisms systematically restrict particular positions?
Knowledge rents	Returns linked to controlled scarcity of epistemic objects, capacities, or access pathways	What portion of an economic return depends on maintaining a scarce epistemic position or bottleneck?

limited for specified positions, together with the access conditions, capacities, institutional arrangements, linguistic and technical interfaces, exclusion mechanisms, temporal conditions, and economic consequences through which that limitation is produced or sustained.

Definition 17.14 treats scarcity as relational and function-specific. The same codified knowledge can be abundant for one function and scarce for another. A dataset can be abundant as downloadable files yet scarce as a verified basis for policy if documentation, provenance, computational resources, or domain expertise are limited. An educational lecture can be widely available while sustained mentorship, feedback, laboratory access, or recognized certification remain scarce. A public standard can be accessible as text while implementation competence remains concentrated in specialized firms or professional communities.

Table 17.2 summarizes the eight dimensions developed in this section. The dimensions can coexist and reinforce one another, yet they identify different bottlenecks and therefore imply different empirical and institutional questions.

The scarcity profile also has a temporal dimension. Knowledge that is currently scarce can become abundant through education, publication, standardization, translation, infrastructure investment, institutional reform, or technological change. Conversely, knowledge can become scarce through skill loss, archive degradation, organizational exit, enclosure, language shift, obsolete formats, withdrawal of infrastructure, or concentration of verification capacity. Scarcity should therefore be studied as a process as well as a state.

17.2.1 Access

Access is the first scarcity mechanism because symbolic availability and practical reachability can diverge sharply. Section 17.1.7 distinguished legal ownership from access, competence, attribution, stewardship, infrastructure control, and dependency. The present subsection narrows the problem to the conditions under which a specified position can obtain and use an epistemic object for a specified purpose.

A useful access analysis includes more than physical or digital possession. An article behind no paywall can remain practically inaccessible to a reader who lacks language competence or the background required to interpret it. An open dataset can remain unusable without metadata, documentation, software, compute, or legal permission for the relevant use. A public administrative record can remain difficult to contest if search, copying, retention, or evidential procedures are costly. A professional body of knowledge can be formally public while entry into the communities that interpret and update it depends on credentials, mentorship, or organizational affiliation.

Definition 17.15 (Epistemic access pathway). An *epistemic access pathway* is the sequence of legal, institutional, linguistic, technical, interpretive, and temporal conditions through which a position can obtain, inspect, understand, verify, retain, apply, or contest a specified epistemic object or claim.

Definition 17.15 makes access purpose-specific. Reading a document, reproducing an analysis, using a dataset commercially, challenging an administrative decision, and applying a clinical protocol can require different pathways even when they involve the same epistemic object. Access can also be partial. A position may inspect a model's output while lacking its training data, documentation, parameter history, or validation record. Another may possess the raw data while lacking authority to publish or act upon them.

The distinction between resources and effective opportunity developed in capability-oriented economics provides a useful precedent for this treatment. Sen emphasizes that formally similar resources can generate different substantive opportunities because conversion conditions differ (Sen 1999). Applied here, nominal access to information can coexist with strong inequality in the capacity to convert that information into understanding, action, participation, or remedy.

Proposition 17.16 (Availability–access non-equivalence). *The availability of an epistemic object does not by itself establish practical epistemic access where use depends on complementary legal, institutional, linguistic, technical, interpretive, or temporal conditions.*

Proposition 17.16 is especially important for open and digital environments. Lowering the marginal cost of reproduction can reduce one scarcity while leaving complementary scarcities intact. The relevant empirical question is therefore which step of the access pathway remains binding for the position and purpose under study.

17.2.2 Expertise

Expertise introduces a second form of scarcity. Codified content can be widely distributed while the competence required to interpret, verify, adapt, or generate knowl-

edge remains comparatively concentrated. Section 17.1.2 treated knowledge as capacity. The present subsection focuses on the scarcity of that capacity and on the institutional conditions under which expertise becomes economically consequential.

Expertise is multidimensional. It can include conceptual understanding, procedural skill, tacit recognition, diagnostic judgment, model criticism, experimental technique, contextual memory, and the ability to distinguish meaningful variation from noise. Different tasks can require different combinations. The expertise needed to execute a standard procedure can differ from the expertise required to audit that procedure, design a replacement, explain its limitations, or teach it to others.

Scarcity of expertise can arise from long training periods, limited mentorship, rare experience, specialized equipment, costly practice, safety requirements, institutional bottlenecks, or the cumulative character of learning. Becker's human-capital analysis provides one economic precedent for treating education and training as investments in productive capacity (Becker 1964). GRE retains the investment insight while representing competence as relationally generated through learning histories, institutional recognition, material conditions, and opportunities for practice.

Expertise should also be distinguished from recognized authority. A person can possess substantial competence without a credential or organizational role that permits its exercise. Conversely, a credential can carry institutional authority while only imperfectly representing current competence. The distinction matters because scarcity of recognized expertise can be produced either by scarcity of underlying competence or by scarcity of positions authorized to exercise it.

Definition 17.17 (Expertise-scarcity profile). An *expertise-scarcity profile* records the competences required for a specified epistemic-economic function, the positions possessing or lacking those competences, the learning and practice pathways through which they can be formed, the recognition mechanisms through which they become institutionally actionable, and the consequences of their limited distribution.

Proposition 17.18 (Expertise-recognition non-equivalence). *Scarcity of epistemic competence and scarcity of recognized authority are analytically distinct even when credentials, professional standing, or institutional roles connect them in practice.*

Proposition 17.18 prevents a common compression. A shortage of licensed professionals may reflect limited training capacity, restrictive recognition rules, geographic distribution, working conditions, migration barriers, or several mechanisms at once. Governance responses differ depending on which mechanism is binding.

Expertise can also become a bottleneck in systems that otherwise appear informationally abundant. As automated systems generate more analyses, reports, code, models, or recommendations, the scarce function may shift toward verification, integration, accountability, or judgment. Section 17.3 will examine that abundance-scarcity transformation directly. The present point is narrower: scarcity can reside in the competence needed to make abundant symbolic outputs epistemically and economically usable.

17.2.3 Education

Education is a principal institutional pathway through which expertise and broader epistemic capacities are formed. Its scarcity therefore concerns more than the number of available seats. Educational access can depend on cost, geography, time, prior preparation, language, care obligations, disability access, documentation, institutional eligibility, information about opportunities, and the ability to remain within a learning pathway long enough for capability formation to occur.

The economic significance of education also exceeds immediate labor productivity. Education can expand interpretive capacity, participation, mobility across epistemic domains, access to professional communities, and the ability to evaluate or contest claims. Capability-oriented analysis is again useful because formal access to schooling and substantive educational opportunity can diverge when conversion conditions differ (Sen 1999). The same curriculum can generate different effective capacities when students differ in language, prior preparation, time, safety, technology, mentoring, financial security, or institutional recognition.

GRE therefore treats education as a generative relation as well as a resource allocation. A learning process can change the future epistemic option space of the learner by enabling entry into later fields, increasing the range of claims that can be assessed, and creating relationships through which subsequent knowledge becomes accessible. Educational scarcity can consequently compound historically. Limited early access can reduce eligibility for later education, credentials, occupations, research infrastructure, or authoritative roles.

Definition 17.19 (Educational epistemic pathway). *An educational epistemic pathway is a temporally ordered configuration of learning relations, instructional resources, practice opportunities, feedback, credentials, institutional transitions, and enabling conditions through which later epistemic capacities and access positions are formed.*

Definition 17.19 supports analysis of both formal and informal education. Apprenticeship, professional practice, community learning, research supervision, libraries, peer groups, online instruction, and workplace learning can all participate in capacity formation. Their economic significance depends on what later capacities and access relations they generate.

Credentials require separate treatment from learning. Credentials can certify achievement, reduce information costs, organize professional standards, and create predictable admission rules. They can also become gates whose scarcity is only partly connected to underlying competence. The analytical question is therefore how educational formation, recognized qualification, and later access are connected in the field under study.

Proposition 17.20 (Education-path dependence). *Where later epistemic access depends on capacities, credentials, or institutional relations generated through earlier education, educational scarcity can become historically cumulative even when each later gate is formally open under stated rules.*

Proposition 17.20 does not imply that educational trajectories are fixed. Bridging programmes, recognition of prior learning, open educational resources, alternative credentials, mentoring, public provision, and institutional reform can reopen pathways. It indicates that scarcity should be traced across sequences rather than inferred

from one contemporaneous admission rule.

17.2.4 Institutional Position

Institutional position creates another source of knowledge scarcity because economically relevant knowledge is often embedded in organizations, professions, regulatory systems, laboratories, platforms, archives, and trusted networks. Formal public availability can coexist with privileged access arising from membership, employment, appointment, accreditation, security clearance, contractual relation, research affiliation, or recognized standing.

North's institutional analysis emphasizes that rules structure transaction possibilities and incentives rather than merely recording choices after they occur (North 1990). In epistemic fields, institutional rules can determine who may inspect records, enter laboratories, access administrative data, participate in standards committees, submit evidence, receive internal reports, obtain research funding, or speak with recognized authority. These positions can be economically valuable even when the underlying knowledge is neither privately owned nor scarce in a physical sense.

Institutional position also affects trust and uptake. A claim produced by a recognized laboratory, regulatory body, university, standards organization, or professional association can receive attention and authority that an equivalent claim from an unrecognized source does not automatically receive. Such recognition can be justified by quality-control institutions, accumulated reliability, accountability, or specialized competence. It can also reproduce exclusion where standing becomes detached from relevant epistemic capacity or where alternative knowledge systems lack routes to recognition.

Definition 17.21 (Institutional epistemic position). An *institutional epistemic position* is a recognized role or standing that conditions a position's access to epistemic objects, infrastructures, decision forums, evidential channels, certification functions, or authoritative interpretation within a specified institutional field.

Institutional epistemic positions are heterogeneous. Membership can grant access to internal records without decision authority. Employment can provide laboratory access without publication rights. Accreditation can authorize certification without conferring ownership of the underlying knowledge. A regulator can possess evidential access while remaining institutionally separated from the organizations that generated the data. The relevant profile should therefore specify the bundle of epistemic rights and capacities attached to the position.

Proposition 17.22 (Position–knowledge distinction). *Institutional epistemic position can condition access and authority without establishing the epistemic adequacy of the knowledge held by the position, while epistemic competence can exist without the institutional standing required for consequential uptake.*

This distinction prepares later analysis of epistemic asymmetry and institutions. Scarcity can be located in knowledge itself, in the positions through which knowledge becomes actionable, or in the conversion mechanism connecting competence to recognized authority.

17.2.5 Linguistic Access

Linguistic access is an epistemic-economic condition because language participates in the transmission, interpretation, contestation, and generation of knowledge. A document can be materially available while remaining practically inaccessible to positions unable to read the relevant language or specialized register. Translation can reduce this barrier; yet translation itself requires resources, competence, contextual knowledge, and decisions about terminology, ambiguity, and equivalence.

Language scarcity appears at several levels. Everyday language can condition entry into education, employment, administration, and public services. Professional registers can condition access to law, medicine, finance, engineering, or scientific debate. Mathematical and computational languages can function as specialized interfaces to technical knowledge. Institutional vocabularies and classifications can determine whether a person can formulate a claim in terms recognized by a decision system. The same position can therefore possess general linguistic competence while lacking access to the register required for a particular epistemic-economic function.

Linguistic access also has a generative dimension. A language provides concepts, distinctions, metaphors, histories, and communities of interpretation that can shape which questions become easy to formulate and which relations become visible. This observation does not imply linguistic determinism. It indicates that translation among epistemic systems can involve conceptual work beyond lexical substitution.

Definition 17.23 (Linguistic epistemic access). *Linguistic epistemic access* is the practical capacity to receive, interpret, express, translate, and contest epistemically consequential content in the linguistic or symbolic forms through which a specified field organizes knowledge and action.

Translation technologies, multilingual publication, interpreters, standardized terminology, language education, and accessible communication can widen linguistic epistemic access. Their adequacy remains purpose-specific. A translation sufficient for general orientation may be insufficient for legal interpretation, scientific replication, contractual commitment, or technical safety. Tacit context, historical connotation, category boundaries, and field-specific conventions can remain consequential after surface translation.

Proposition 17.24 (Translation–access scope condition). *Translation expands epistemic access to the extent that it preserves the distinctions, context, evidential relations, and practical functions material to the intended use; symbolic convertibility alone does not establish functional equivalence across epistemic settings.*

Proposition 17.24 preserves the broader GRE principle against premature equivalence. Linguistic access can often be improved substantially while still leaving domain-specific remainder that requires interpretation, negotiation, or parallel representation.

17.2.6 Technical Access

Technical access concerns the material and computational complements through which epistemic objects can be generated, retrieved, inspected, verified, or used. Digital knowledge environments make this dimension increasingly visible. Public

documentation can remain economically inaccessible where users lack suitable hardware, network connectivity, software, authentication, data formats, compute capacity, instrumentation, storage, or maintenance support.

Technical access is layered. A position can possess network access while lacking authorization to a repository, possess repository access while lacking compatible software, possess software while lacking computational capacity, or possess compute while lacking the data rights required for the intended analysis. Scientific knowledge can depend on instruments that are expensive, geographically concentrated, or institutionally controlled. Industrial know-how can depend on machine tools, clean rooms, test environments, or production-scale feedback unavailable to positions that possess the written design.

The technical layer therefore affects both use and verification. Reproducibility of a computational result can require versioned code, dependency environments, hardware characteristics, datasets, random seeds, documentation, and substantial compute. A formal commitment to transparency can consequently coexist with practical verification scarcity when the complementary technical stack is unavailable.

Definition 17.25 (Epistemic technical-access stack). An *epistemic technical-access stack* is the configuration of hardware, software, data, compute, networks, instruments, standards, interfaces, authentication, documentation, and maintenance conditions required for a specified position to generate, inspect, verify, reproduce, or apply an epistemic object.

The stack concept avoids treating technical access as one binary variable. Different layers can be controlled by different institutions, and a bottleneck at one layer can dominate the practical value of openness elsewhere. The configuration can also change historically as standards evolve, software becomes obsolete, compute costs fall, proprietary interfaces close, or public infrastructure expands.

Proposition 17.26 (Technical-complementarity condition). *Where effective use or verification of knowledge depends on a complementary technical stack, reducing scarcity at one technical layer need not remove epistemic scarcity when another layer remains binding for the specified function.*

This proposition prepares Sections 17.7 and 17.11, where computational asymmetry and epistemic infrastructure receive fuller treatment. Here the point is that technical access is one mechanism through which apparently abundant knowledge can remain economically scarce.

17.2.7 Epistemic Exclusion

Scarcity becomes epistemic exclusion when limitation is generated or stabilized through a selective relational mechanism that restricts particular positions in their access to, recognition within, contribution to, or contestation of an epistemic field. This distinction matters because scarcity can arise without exclusion. A rare expertise may be scarce because training is intrinsically demanding; a telescope may be scarce because construction is costly; a historical archive may be incomplete because records were never created. Exclusion adds a relational mechanism through which some positions face systematically different epistemic possibilities.

Exclusion can operate through price, eligibility, credentials, classification, membership, secrecy, location, language, inaccessible design, identity verification, publication rules, professional norms, technical standards, discriminatory practice, or the absence of recognized channels for testimony and interpretation. Several mechanisms can coexist. A position may have legal access to an institution while being unable to participate because documentation, language, scheduling, technical interface, or social recognition creates an effective barrier.

Fricker's account of epistemic injustice provides an important philosophical precedent for analyzing credibility and interpretive resources as sites of injustice (Fricker 2007). The present section uses a narrower economic object. It asks how selective epistemic barriers condition access to education, work, markets, finance, public services, research infrastructure, decision procedures, or future capacity formation. The normative evaluation of these barriers belongs more fully to Section 17.12; the present task is descriptive and causal.

Definition 17.27 (Epistemic exclusion mechanism). *An epistemic exclusion mechanism is a relational, institutional, linguistic, technical, classificatory, or economic process that selectively restricts specified positions from consequential access to, participation in, recognition within, verification of, contribution to, or contestation of an epistemic field.*

The definition is intentionally selective. Unequal outcomes do not by themselves establish exclusion. A claim of exclusion requires evidence of the mechanism that differentiates access or standing. Likewise, exclusion does not automatically establish injustice. Some exclusions can support privacy, safety, fiduciary obligation, confidentiality, research integrity, or protection against misuse. Their legitimacy depends on purpose, scope, proportionality, alternatives, contestability, and incidence.

Proposition 17.28 (Scarcity–exclusion distinction). *Epistemic scarcity supports a claim of epistemic exclusion only where a selective mechanism materially differentiates the epistemic possibilities available to specified positions; scarcity arising from other causes requires separate characterization.*

Exclusion can also become generative. Restricted access to one educational or institutional field can reduce the capacity to enter later fields. Exclusion from recognized evidence production can make later contributions less visible. Technical incompatibility can prevent participation in the standards process that would otherwise revise the incompatibility. These recursive pathways connect scarcity to the persistent asymmetries developed in Section 17.7.

17.2.8 Knowledge Rents

The final scarcity mechanism concerns economic returns associated with control over scarce epistemic positions. Information and knowledge have unusual economic properties because disclosure, replication, and appropriation do not follow the same pattern as many ordinary rival goods. Arrow's analysis of invention emphasized uncertainty in information production and the difficulty of appropriating informational returns once information is disclosed (Arrow 1962). Institutions therefore organize scarcity through patents, secrecy, licensing, credentials, exclusive data access, specialized infrastructure, standards, reputation, membership, and other mechanisms that

can preserve incentives, recover costs, protect legitimate interests, or create strategic bottlenecks.

The present subsection uses *knowledge rent* in a deliberately scoped sense. It does not classify every return to expertise or intellectual production as rent. Skilled labor can receive compensation for time, training, risk, judgment, and responsibility. A research organization can require revenue to maintain laboratories and staff. A publisher can incur editorial and preservation costs. A software provider can incur continuing development and security costs. Rent analysis requires a specified counterfactual and an identified scarcity mechanism.

Definition 17.29 (Knowledge-scarcity rent). A *knowledge-scarcity rent* is the portion of an economic return attributable, within a specified institutional counterfactual, to control over a scarce epistemic object, capacity, recognition position, access pathway, or enabling infrastructure rather than to the contemporaneous costs required to produce, maintain, or responsibly provide the relevant epistemic function.

Definition 17.29 is analytical rather than automatically normative. A scarcity rent can arise from a socially chosen institution that supports investment, disclosure, quality assurance, or long-horizon preservation. It can also arise from avoidable exclusion, strategic enclosure, switching costs, proprietary standards, concentrated certification, or control of complementary infrastructure. Evaluation requires attention to how the scarcity was produced, what function it serves, how returns are distributed, whether alternatives exist, and what generative consequences follow.

Knowledge rents can also depend on positional scarcity rather than content scarcity. A widely known method may yield high returns to the small number of organizations authorized to certify its use. Public information can support rents when one platform controls the audience or interface through which the information becomes economically valuable. An open standard can coexist with rents arising from scarce implementation expertise or complementary hardware. These cases reinforce the distinction among knowledge content, capacity, institutional position, and infrastructure established throughout Sections 17.1–17.2.

Proposition 17.30 (Rent-source traceability). A *claim of knowledge-scarcity rent* requires a specified scarcity mechanism and counterfactual capable of distinguishing returns attributable to control of the scarce epistemic position from returns associated with production, maintenance, risk, responsibility, or other economically relevant inputs.

The proposition keeps the present section narrower than the knowledge-capital analysis in Section 17.8. Section 17.8 will examine accumulation, ownership, control, infrastructure, expansion, rents, and intergenerational advantage as a connected capital architecture. The current section establishes only the scarcity-side mechanism: epistemic returns can depend on controlled bottlenecks even when the underlying symbolic content is reproducible at low marginal cost.

Knowledge scarcity can lie in access, expertise, education, institutional standing, language, technical complements, exclusion, or controlled bottlenecks, and these mechanisms can convert over time. Section 17.3 examines the complementary case: epistemic abundance can shift scarcity toward verification, attention, orientation, trust, and other capacities required for use.

17.3 Epistemic Abundance

Section 17.2 examined knowledge scarcity as a multidimensional condition involving access, expertise, education, institutional standing, language, technical complements, exclusion, and controlled bottlenecks. The role of the present section is to examine the complementary configuration in which epistemic objects or symbolic outputs become abundant while the capacities required to evaluate, select, orient, verify, or trust them remain limited. Its objective is to distinguish abundance of information, abundance of knowledge-generating activity, AI-generated content, and symbolic abundance from the downstream scarcities that can emerge around verification, attention, orientation, and trust. The discussion is relational and process-sensitive. Abundance is treated as a position- and function-specific condition rather than as a claim that the epistemic field as a whole has ceased to contain scarcity.

An epistemic field can therefore become abundant along one dimension while remaining scarce along another. A large literature can coexist with scarce synthesis. Open data can coexist with scarce interpretive capacity. Automated systems can generate many candidate answers while reliable verification remains costly. A scientific field can produce more papers than any individual can read while a small number of laboratories retain scarce experimental infrastructure. The relevant analytical problem is consequently the changing location of scarcity within an expanding epistemic system.

Definition 17.31 (Epistemic-abundance profile). An *epistemic-abundance profile* records the epistemic objects, symbolic outputs, generative capacities, production rates, replication conditions, distribution channels, receiving positions, complementary verification capacities, attention structures, orientation mechanisms, trust relations, and temporal horizons through which abundance becomes economically consequential in a specified field.

Definition 17.31 prevents abundance from being represented by output volume alone. The same increase in symbolic production can improve access for one position, create overload for another, increase the value of trusted filters for a third, and leave a fourth position unaffected because the binding constraint lies in language, infrastructure, or institutional standing. Table 17.3 summarizes the dimensions developed below.

The rows in Table 17.3 interact without collapsing into a single abundance index. A system can generate abundant information while producing little new explanatory knowledge. AI can generate abundant symbolic content while increasing demand for verification. Abundant representations can increase dependence on trusted intermediaries. Improved verification infrastructure can reduce one bottleneck while increasing attention demands through a larger volume of validated material. The location of epistemic scarcity can therefore move as the production architecture changes.

Proposition 17.32 (Abundance–scarcity coexistence). *Epistemic abundance in one object, process, or layer does not establish the disappearance of epistemic scarcity where consequential use continues to depend on limited complementary capacities, infrastructures, positions, or institutional pathways.*

Proposition 17.32 provides the section’s governing discipline. Abundance and

Table 17.3: Dimensions of epistemic abundance and associated scarcity shifts in substantive GRE analysis.

Dimension	Primary abundance object	Characteristic analytical question
Abundant information	Reproducible signals, records, data, documents, and communicated claims	Which uses become easier when informational availability rises, and which complementary conditions remain binding?
Abundant knowledge generation	Expanded capacity to produce analyses, explanations, models, hypotheses, and candidate solutions	Does higher production expand warranted knowledge, or shift scarcity toward evaluation, synthesis, and verification?
AI-generated content	Machine-produced symbolic artifacts at low marginal generation cost and high throughput	Which outputs become economically useful, and which require additional grounding, provenance, verification, or accountable judgment?
Symbolic abundance	Proliferation of text, images, indicators, credentials, classifications, reports, and other representations	How does increased representational supply affect authenticity, provenance, legibility, and the relation between symbol and referent?
Verification scarcity	Limited capacity to test, audit, reproduce, authenticate, or establish the standing of abundant claims	Which verification pathways become bottlenecks as candidate claims and artifacts multiply?
Attention scarcity	Finite individual and institutional reception capacity under expanding informational supply	Which objects receive notice, sustained processing, and response when available content exceeds processing capacity?
Orientation scarcity	Limited capacity to select worthwhile questions, trajectories, and priorities among many available possibilities	How are inquiry and action directed when candidate problems and solutions proliferate faster than evaluative orientation?
Trust scarcity	Limited justified willingness to rely on sources, procedures, intermediaries, or claims under representational abundance	Which provenance and institutional conditions support reliance when direct verification is infeasible?

scarcity are not mutually exclusive descriptions of an epistemic economy. They can coexist at different layers of the same process and can generate one another dynamically.

17.3.1 Abundant Information

Information can become abundant when reproduction, storage, communication, search, sensing, publication, or data generation expands more rapidly than the costs associated with producing additional copies or observations. Digital infrastructures are especially important because many informational objects can be reproduced at low marginal cost once created. Arrow's analysis of information and invention remains relevant here because informational disclosure and appropriation differ from ordinary rival goods (Arrow 1962). GRE adds a relational question: abundance depends on which position, purpose, and access pathway are under analysis.

A large public dataset is abundant in one sense if many users can obtain identical copies. It can remain scarce in another sense if only a small number of organizations possess the compute, expertise, authorization, or contextual knowledge required to use it responsibly. A library can contain millions of documents while a researcher

lacks the language or disciplinary competence required to identify the relevant subset. Real-time sensor systems can produce continuous streams while institutional procedures allow only a small portion of the observations to affect decisions.

Definition 17.33 (Informational abundance). *Informational abundance* is a condition in which the availability, reproducibility, production rate, or accessible variety of specified informational objects substantially exceeds a reference level relevant to a defined position and function.

The reference level in Definition 17.33 matters. A thousand records can be abundant for a narrow administrative decision and sparse for a high-dimensional scientific inference. An information stream can be abundant relative to storage capacity but scarce relative to the diversity of conditions it is expected to represent. Abundance should therefore be specified relative to the epistemic-economic function rather than inferred from absolute quantity.

Informational abundance can improve economic possibility. Search costs can fall when records are indexed. Distributed actors can coordinate through common standards and shared databases. Repeated observation can reveal variation that isolated measurements could not. Open educational resources can broaden entry into fields formerly dependent on local possession of scarce texts. Yet these benefits depend on conversion conditions. Availability does not automatically produce comprehension, reliable inference, institutional standing, or practical action.

Proposition 17.34 (Informational abundance–capacity divergence). *An increase in informational availability can coexist with persistent or increasing inequality in epistemic capacity when positions differ in the complementary resources, competences, infrastructures, authority, or time required to convert available information into warranted understanding or action.*

Proposition 17.34 connects abundance directly to Section 17.2. Lower reproduction cost can remove one access barrier while leaving expertise, education, institutional position, language, technical access, or recognition as binding scarcities. Abundance can consequently redistribute advantage toward positions best able to process, verify, combine, and operationalize the expanding information supply.

17.3.2 Abundant Knowledge Generation

Epistemic abundance can arise at the level of generation as well as stored information. Research organizations, distributed communities, computational systems, simulation environments, automated instruments, and AI-assisted workflows can increase the rate at which hypotheses, models, explanations, interpretations, designs, and candidate solutions are produced. The resulting condition is analytically different from simple informational abundance because generation changes the flow of candidate epistemic objects rather than only the stock available for retrieval.

The distinction between generation and validation is essential. A laboratory can generate many experimental measurements while only a subset survive quality control. A forecasting system can produce thousands of scenarios while only some satisfy calibration requirements. A scholarly field can generate more manuscripts than existing review institutions can evaluate. A software system can generate many can-

candidate implementations while testing and security review remain costly. High generative throughput therefore changes the relative importance of selection, synthesis, verification, and integration.

Definition 17.35 (Epistemic-generation abundance). *Epistemic-generation abundance* is a condition in which a specified field can produce candidate epistemic objects, interpretations, models, hypotheses, designs, or solutions at a rate or variety substantially greater than the reference capacity for evaluation, integration, application, or preservation.

Definition 17.35 deliberately uses the term *candidate*. Generation can enlarge the epistemic search space without ensuring that each generated object is accurate, novel, relevant, coherent, or worth preserving. The economic significance lies partly in this asymmetry between production and subsequent evaluative work.

Abundant generation can be valuable even when most outputs are discarded. Search processes often depend on generating variation before selection. Scientific inquiry can benefit from alternative models, replication attempts, counterexamples, and competing interpretations. Engineering can benefit from many candidate designs. Creative and entrepreneurial activity can benefit from cheap prototyping. Yet expansion can also increase duplication, noise, review burden, and the difficulty of identifying consequential novelty. The balance depends on the architecture connecting generation to filtering and learning.

Proposition 17.36 (Generation–evaluation divergence). *Expansion of epistemic generation does not by itself establish a corresponding expansion of warranted knowledge when evaluation, synthesis, verification, integration, preservation, or practical uptake remain comparatively scarce.*

The proposition shifts analysis from the volume of output to the whole generative pathway. A field can become highly productive in candidate claims while remaining bottlenecked by replication capacity, expert review, long-horizon observation, institutional memory, or responsible application. The next subsection examines one contemporary mechanism capable of substantially increasing candidate symbolic generation.

17.3.3 AI-Generated Content

Artificial generative systems can lower the marginal cost and time required to produce text, images, code, summaries, classifications, synthetic examples, and other symbolic artifacts. The present subsection treats this capability as an epistemic-economic mechanism of abundance. It does not attempt to settle the broader questions of human–AI capability asymmetry, substitution, collective agency, or governance that belong to Chapter 18.

The analytical starting point is the distinction among symbolic output, information, and warranted knowledge. A generated answer can be fluent, relevant, and economically useful while still requiring verification. A generated citation can have the surface form of scholarship while failing to refer to an existing source. Generated code can satisfy an immediate functional test while containing hidden vulnerabilities. Generated summaries can reduce search costs while omitting context important

to a later decision. Bender and colleagues emphasize the danger of equating fluent language generation with semantic understanding or grounded knowledge (Bender et al. 2021). GRE uses that distinction economically: lower symbolic-generation cost can shift the scarce work toward grounding, checking, provenance, judgment, and responsibility.

Definition 17.37 (AI-mediated epistemic abundance). *AI-mediated epistemic abundance* is a condition in which artificial systems materially expand the speed, scale, variety, or accessibility of candidate epistemic or symbolic outputs within a specified field, thereby altering the distribution of generative, evaluative, verificatory, interpretive, or decision capacities.

The definition includes outputs that become useful intermediates even when they are not independently accepted as knowledge. A generated translation can improve access. A synthetic example can support teaching. A model-generated hypothesis can redirect experimentation. A draft can reduce the cost of initial formulation. An automated extraction can make a large archive searchable. In each case, the economic effect depends on the relation between generation and subsequent human or institutional uptake.

AI-mediated abundance can therefore create complementary scarcities. Domain experts may become bottlenecks because more outputs require review. Organizations may require new provenance and logging systems. Verification costs can rise when plausible artifacts are easier to produce than reliable checks. Attention can shift toward prompt specification, evaluation, exception handling, and monitoring. Responsibility can become difficult to assign when symbolic production is distributed across users, models, data pipelines, tools, and institutional processes.

Proposition 17.38 (AI-output–knowledge non-equivalence). *The production of an AI-generated symbolic artifact does not by itself establish the artifact’s status as warranted knowledge; that status depends on the evidential, interpretive, verificatory, provenance, and institutional conditions relevant to its intended use.*

This proposition preserves a useful middle position. AI-generated content is neither dismissed as economically irrelevant nor promoted automatically to knowledge. Its role is pathway-dependent. The same output can function as brainstorming material in one setting, an auditable intermediate in another, a low-risk convenience in a third, and an unacceptable evidential basis in a fourth. The relevant economic analysis follows the artifact through the conditions of production, verification, authorization, and use.

17.3.4 Symbolic Abundance

Epistemic abundance also appears as symbolic abundance: proliferation of texts, images, indicators, certificates, rankings, classifications, profiles, dashboards, reports, labels, and other representations through which economic actors make persons, organizations, products, risks, claims, and states of the world legible. Chapter 1 introduced symbolic abundance as part of a wider representational problem. The present subsection gives the concept a narrower epistemic-economic role within the architecture of Chapter 17.

Symbols matter economically because coordination often depends on representations that travel farther than direct observation. A credential represents a history of education or certification. A credit score condenses records into a portable classification. A dashboard represents aspects of organizational performance. A scientific paper represents a research process. An identity token represents a claim about a person or institution. The economic value of these representations depends partly on how reliably users can connect symbol, provenance, procedure, and referent.

Definition 17.39 (Symbolic-abundance profile). A *symbolic-abundance profile* records the classes of representations proliferating within a specified field, their production and replication conditions, the referents or institutional functions they purport to represent, the provenance and authentication mechanisms attached to them, and the consequences of their abundance for legibility, verification, coordination, and trust.

Abundance can lower barriers to expression and representation. More actors can publish, document, signal, classify, visualize, and communicate. It can also weaken the diagnostic value of symbols whose usefulness depended partly on scarcity or costly production. A polished report may once have signaled substantial organizational investment; inexpensive generation can weaken that inference. A credential can lose signaling power when comparable symbols proliferate faster than the capacities they are expected to represent. A ranking can become less informative when strategic optimization targets the measure rather than the underlying object.

Porter's history of quantitative objectivity shows why portable procedures and standardized representations became institutionally valuable where personal trust was insufficient (Porter 1995). Symbolic abundance intensifies the same organizational problem. Institutions need ways to determine which representations were produced by which procedures, which histories they encode, what they omit, and what kind of reliance they can support.

Proposition 17.40 (Symbolic abundance–referential reliability distinction). *An increase in the supply or formal quality of symbolic representations does not by itself establish improved referential reliability, because the relation among symbol, provenance, production procedure, and represented object can vary independently of surface abundance.*

The proposition helps locate a major scarcity shift. When persuasive symbolic form becomes inexpensive, authenticity, provenance, verification, and recognized procedures can become comparatively more valuable. The result is not a universal decline in trust. Digital systems can improve traceability, standardization, and auditability. The analytical point is that abundance changes which institutional signals carry diagnostic weight.

17.3.5 Verification Scarcity

As information and symbolic generation expand, verification can become a relatively scarce complement. Verification is used here broadly to include authentication, evidential checking, replication, audit, source evaluation, model validation, provenance inspection, consistency testing, and other procedures through which the standing of a claim or artifact is assessed for a specified purpose.

Verification is itself heterogeneous. Authenticating the source of a document differs from establishing the truth of its contents. Reproducing a computational result differs from validating the assumptions of the model. Confirming that an image is unaltered differs from determining whether the depicted event is representative. Checking a citation differs from evaluating the argument that relies on it. A field can therefore possess strong verification capacity at one layer and weak capacity at another.

Definition 17.41 (Verification-capacity profile). A *verification-capacity profile* records the claims or artifacts requiring verification, the applicable standards, evidential inputs, expertise, technical infrastructure, provenance records, time, costs, authorized positions, error tolerances, and escalation pathways through which their standing can be assessed for a specified use.

Verification scarcity can grow even when verification technology improves. If generation expands faster than checking capacity, the ratio of candidate objects to available verification effort can increase. Cheap synthesis can create more claims requiring source inspection. Automated code generation can create more software requiring testing. High-throughput experiments can generate more results requiring quality control. Continuous sensors can create more anomalies requiring adjudication. The scarce object is consequently not an abstract supply of truth, but the practical capacity to establish warranted reliance at the necessary scale and speed.

Proposition 17.42 (Generation–verification asymmetry). *Where the rate or variety of candidate epistemic production grows faster than the capacity to verify outputs to the standard required for consequential use, epistemic abundance can increase verification scarcity even as the absolute capacity for verification also improves.*

This proposition is relative rather than pessimistic. A verification system can become much more capable while still becoming the binding constraint because generation expands even faster. The response can include better provenance, sampling, risk-tiered review, automated checking, reproducibility infrastructure, trusted certification, stronger source standards, or narrower use conditions. Each response redistributes costs and authority and can create new bottlenecks.

Verification scarcity also interacts with power. Positions controlling scarce audit, certification, authentication, or validation pathways can acquire strategic importance when other positions depend on them for market access, publication, licensing, financing, or institutional legitimacy. The power claim still requires the conversion mechanism established in Chapter 16. The present section identifies only the scarcity condition from which such power can sometimes emerge.

17.3.6 Attention Scarcity

Attention is another scarcity that can become more visible as informational supply expands. Simon’s account of information-rich environments captured the basic relation: abundance of information consumes the attention of its recipients (Simon 1971). The present subsection establishes that relation as part of the abundance architecture while reserving the detailed economic analysis of attention allocation, capture, visibility, and governance for Section 17.4.

Abundant information creates more possible objects of notice than individuals or

institutions can process with equal depth. The constraint can appear at different stages. Search systems determine which objects enter the candidate set. Organizational queues determine what receives staff time. Editorial and review systems determine what receives scrutiny. Meeting agendas determine what receives collective deliberation. Dashboards and alerts determine what remains continuously visible. Attention scarcity is therefore shaped by infrastructure and institutional design as well as cognition.

Definition 17.43 (Abundance-induced attention scarcity). *Abundance-induced attention scarcity* is a condition in which growth in available epistemic objects or signals outpaces the reception, processing, deliberation, or response capacity relevant to a specified position or institution, thereby increasing the selectivity of attention allocation.

The economic consequence is not simply that some information remains unread. Selective attention can determine which risks are investigated, which research problems receive funding, which products become visible, which anomalies trigger review, which complaints receive response, and which future possibilities enter planning. The scarcity therefore affects both current allocation and later generative pathways.

Proposition 17.44 (Abundance–attention displacement). *When epistemic supply expands faster than effective attention capacity, additional information can improve the available choice set while simultaneously increasing the probability that some consequential objects receive reduced notice, delayed processing, or no institutional uptake.*

The proposition avoids equating overload with inevitable decline. Better search, filtering, delegation, summarization, triage, and institutional specialization can increase effective attention capacity. Yet these mechanisms also determine visibility and can introduce their own asymmetries. Section 17.4 therefore treats attention as a substantive economic object in its own right.

17.3.7 Orientation Scarcity

Attention selects what receives notice; orientation organizes a more sustained direction of inquiry or action. Chapter 16 treated orientation as a governance configuration linking problems, temporal horizons, evidential priorities, affected positions, and resource commitments. Epistemic abundance increases the importance of this function because more available questions, models, explanations, technologies, and possible interventions can exceed the capacity to pursue them seriously.

Orientation scarcity is therefore different from ignorance. A research community can know about many possible questions while lacking the capacity to decide which deserve sustained investigation. A firm can possess extensive market intelligence while lacking a coherent basis for choosing among technological trajectories. A public institution can receive many credible risks and proposals while lacking the resources and normative framework required to prioritize them. Abundance of possible directions can increase the economic value of problem formation, sequencing, judgment, and commitment.

Definition 17.45 (Epistemic-orientation scarcity). *Epistemic-orientation scarcity* is a

condition in which the number, diversity, or uncertainty of plausible epistemic or practical directions exceeds the capacity of a specified position or institution to evaluate, prioritize, commit to, sustain, and revise those directions responsibly.

Orientation scarcity can become acute when answer production becomes cheaper than problem formation. A system capable of producing rapid responses to well-formed prompts can still leave unresolved which questions matter, which assumptions deserve challenge, which temporal horizons should govern evaluation, which domains should remain protected from optimization, or which lines of inquiry justify scarce collective attention. The scarcity consequently sits partly in framing and judgment rather than information retrieval.

This point prepares Sections 17.5 and 17.6, where curiosity, question formation, aesthetic judgment, and epistemic orientation receive fuller treatment. The present section establishes only the abundance-side mechanism: expansion of candidate answers and pathways can raise the relative importance of capacities that select and sustain meaningful directions.

Proposition 17.46 (Answer abundance–orientation non-equivalence). *Expansion in the availability of candidate answers, models, or solutions does not by itself expand epistemic orientation, because orientation also depends on problem formation, evaluative judgment, temporal commitment, priority setting, and the capacity to revise direction.*

The proposition does not imply that orientation must remain centralized or scarce. Distributed communities, plural institutions, exploratory portfolios, and open-ended research can increase orientation diversity. The analytical requirement is to distinguish abundance of possible directions from the capacities and institutions through which some of those directions become sustained trajectories.

17.3.8 Trust Scarcity

Direct verification of every consequential claim is often infeasible. Economic coordination therefore relies on trust in persons, institutions, procedures, standards, credentials, provenance systems, archives, instruments, and intermediaries. Epistemic abundance can change this trust architecture because the number of available claims and representations can grow faster than the capacity for direct verification or long-term familiarity.

Trust is analytically distinct from truth. A trusted source can be mistaken; an untrusted source can be correct. Trust is also distinct from verification. Verification can support trust, but many economic relations require action before complete verification is available. Conversely, repeated trust can reduce verification effort and thereby create vulnerability when the trusted procedure or intermediary fails. The relevant object is therefore justified and institutionally situated reliance under conditions of limited direct checking.

Definition 17.47 (Epistemic-trust scarcity profile). *An epistemic-trust scarcity profile records the claims and decisions for which direct verification is limited, the persons, institutions, procedures, standards, provenance systems, or intermediaries on which reliance is placed, the evidence supporting that reliance, the available alternatives, the consequences of error, and the pathways through which trust can be revised,*

withdrawn, or repaired.

Symbolic abundance can increase the value of reliable provenance and recognized procedure because surface form becomes less diagnostic. Porter's analysis of trust in numbers illustrates one historical response to problems of distance and contested personal authority: standardized procedures can create portable forms of institutional reliance (Porter 1995). Contemporary epistemic economies add digital provenance, authentication, audit trails, reputation systems, verified identities, model documentation, and other devices that attempt to make reliance scalable.

These mechanisms can reduce trust scarcity while creating new dependencies. If only a small number of platforms, certifiers, identity providers, journals, rating agencies, audit firms, or technical infrastructures are treated as credible gateways, trust can become concentrated in intermediaries whose decisions materially condition access to markets or public standing. The relevant power analysis again depends on the consequential mechanism rather than on trust concentration alone.

Proposition 17.48 (Trust-truth non-equivalence). *The degree of reliance placed on an epistemic source, procedure, or intermediary is an insufficient standalone indicator of the truth or adequacy of the claims it supports, even where trust is economically necessary for coordination under limited verification capacity.*

Proposition 17.49 (Abundance-induced trust intermediation). *Where symbolic or informational abundance expands faster than direct verification capacity, economic coordination can become increasingly dependent on provenance, certification, reputation, authentication, and other trust-mediating arrangements, thereby shifting epistemic scarcity toward the credibility and governance of those intermediaries.*

The proposition completes the abundance architecture developed in this section. Abundant information and generative capacity can expand epistemic possibility while relocating scarcity toward verification, attention, orientation, and trust. These scarcities are related without being interchangeable. Verification concerns warranted checking; attention concerns finite reception and processing; orientation concerns sustained direction; trust concerns reliance when direct checking is incomplete. Section 17.4 now isolates attention for fuller economic analysis because attention becomes a central allocation problem once epistemic supply substantially exceeds processing capacity.

17.4 Attention

Section 17.3 showed that epistemic abundance can relocate scarcity toward verification, attention, orientation, and trust. The role of the present section is to isolate attention as a substantive economic object within that wider architecture. Its objective is to distinguish attention capacity, allocation, institutional organization, algorithmic mediation, capture, visibility, power conversion, and governance while preserving the differences among them. The discussion treats attention as a relationally situated and temporally bounded capacity through which some epistemic objects enter sustained processing, deliberation, coordination, or action. It does not assume that attention can be represented adequately as a homogeneous commodity or that greater attention is inherently beneficial.

The classical point of departure is Simon's observation that information-rich environments create scarcity in the attention required to receive and process information (Simon 1971). GRE extends the point in three directions. First, attention is distributed across heterogeneous positions rather than held in one aggregate stock. Second, attention has different qualitative forms: noticing, sustained examination, comparison, deliberation, monitoring, and coordinated response consume different combinations of time, expertise, institutional capacity, and infrastructure. Third, attention allocation can become generative. What receives notice can alter which questions are pursued, which risks are investigated, which persons or organizations become visible, which categories become institutionalized, and which future possibilities enter a practical field.

Definition 17.50 (Attention-economic profile). An *attention-economic profile* records the epistemic objects or signals competing for notice, the positions capable of receiving or processing them, the available attention capacities, the channels and filters through which visibility is organized, the temporal horizon and depth of processing, the allocation and retention mechanisms, the consequences of receiving or failing to receive attention, and the procedures through which attention priorities can be reviewed or revised.

Definition 17.50 keeps attention relational. A report can be highly visible to a specialist team and effectively absent from senior decision-making. A weak signal can receive sustained scientific attention while remaining invisible to market actors. A public issue can receive intense short-horizon media attention while receiving little institutional capacity for long-horizon analysis. The economic object is therefore not attention in the abstract, but a structured relation between candidate objects, receiving positions, processing capacities, and consequential pathways.

Table 17.4 summarizes the eight dimensions developed below.

The rows in Table 17.4 are connected without being interchangeable. Attention can be scarce without being intentionally allocated. Allocation can be institutional without being algorithmic. Algorithmic mediation can alter visibility without constituting attention capture. Unequal visibility can remain consequential without becoming a power relation. Attention governance can reduce one scarcity while generating another, for example by creating reporting or monitoring burdens that consume the capacity it seeks to improve.

Proposition 17.51 (Attention-role non-equivalence). *Evidence that an epistemic object is visible, frequently encountered, institutionally prioritized, deeply processed, or behaviorally consequential does not establish the remaining attention roles, because each depends on distinct receiving capacities, temporal commitments, organizational pathways, and conversion mechanisms.*

Proposition 17.51 prevents a common compression. Visibility is an entry condition for many attention processes, while sustained inquiry, deliberation, and action require additional capacities. A frequently displayed object can be ignored. A rarely encountered anomaly can receive intensive processing once identified. Institutional prioritization can generate staff attention without public salience, and public salience can coexist with weak institutional response.

Table 17.4: Analytical dimensions of attention in the epistemic economy.

Dimension	Primary object	Characteristic analytical question
Scarce attention capacity	Finite reception, processing, deliberation, and response capacity	Which attention function is scarce for which position, and which complementary capacities determine effective use?
Attention allocation	Distribution of notice, processing depth, sequence, and response among competing objects	Which rules, queues, priorities, and resource commitments determine what receives attention?
Institutional attention	Organizational routines, staff, agendas, review cycles, memory, and escalation pathways	How does an institution preserve or redirect attention beyond the cognition of individual members?
Algorithmic attention	Computational ranking, filtering, recommendation, summarization, and alerting	Which objects become more or less visible through algorithmic mediation, according to which objectives and data?
Attention capture	Mechanisms that recurrently retain or redirect scarce attention	When does attraction become a durable conditioning mechanism, and what alternatives or switching costs remain?
Unequal visibility	Uneven probability or depth of becoming noticed, represented, or processed	Which positions, claims, risks, and possibilities remain systematically visible or peripheral, and through which mechanisms?
Attention and power	Conversion of attention asymmetry into consequential conditioning capacity	When does control over visibility or reception materially condition access, standing, demand, investment, or action?
Attention governance	Rules and institutions for prioritization, protection, rotation, escalation, review, and burden allocation	How can attention be organized while preserving anomaly detection, contestability, long-horizon inquiry, and revision?

17.4.1 Attention as Scarce Resource

Attention is scarce because reception and processing take place through finite temporal, cognitive, organizational, and material capacities. Simon's information-rich-world formulation remains especially useful because it treats the relevant scarcity as a consequence of abundant informational sources competing for limited recipient capacity (Simon 1971). Section 17.3 established this relation at the abundance level. The present subsection develops its economic implications.

The word *resource* requires care. Attention can be allocated, protected, depleted, redirected, and combined with complementary inputs, but it does not behave like a homogeneous stock of money or energy. Ten minutes of expert attention cannot always be replaced by ten minutes of novice attention. Ten simultaneous minutes from ten people may not substitute for one hour of continuous concentration. A meeting can aggregate perspectives while fragmenting individual processing. Some tasks require continuity, some require diversity, and some require rapid distributed response. The scarcity therefore concerns functional attention capacity rather than interchangeable units of mental time.

Definition 17.52 (Epistemic attention capacity). *Epistemic attention capacity* is the practically available ability of a specified position or institution to notice, sustain, compare, interpret, deliberate upon, monitor, or respond to epistemic objects over a defined temporal horizon, given its time, expertise, infrastructure, organizational routines, and competing demands.

Definition 17.52 makes attention capacity conditional on function. The capacity to detect anomalies in a sensor stream differs from the capacity to read a long legal record, compare scientific literatures, conduct peer review, or deliberate over conflicting policy evidence. Improvements in search, summarization, delegation, machine assistance, or triage can increase some attention capacities while leaving others unchanged.

Attention also has opportunity cost. Time devoted to one claim, project, patient, risk, market, or research question cannot ordinarily be devoted with equal depth to every alternative at the same moment. At the institutional level, this cost appears in staffing, agenda time, analytical budgets, review cycles, inspection schedules, grant panels, editorial capacity, and management attention. At the individual level, it appears through finite time, fatigue, interruption, switching cost, and the difficulty of sustaining long-horizon inquiry amid competing demands.

Proposition 17.53 (Attention-capacity non-fungibility). *Attention capacities are only partially fungible across tasks when the relevant functions differ in required expertise, continuity, coordination, temporal horizon, infrastructure, or responsibility.*

Proposition 17.53 matters for economic design. Increasing the number of messages a system can receive does not necessarily increase its capacity to adjudicate them. Adding staff can fail to expand attention if the bottleneck lies in scarce expertise or decision authority. Automated filtering can reduce screening cost while increasing the need for audit or exception handling. Attention scarcity should therefore be located at the relevant processing function rather than inferred from aggregate workload alone.

The scarcity can also be endogenous. Institutions can create more reporting requirements than they can interpret, firms can generate more metrics than managers can use, and research systems can increase publication volume faster than peer-review or synthesis capacity. Attention scarcity can consequently be produced by the epistemic architecture itself. This endogenous dimension becomes especially important in Sections 17.4.3 and 17.4.8, where institutional design and attention governance are developed directly.

17.4.2 Attention Allocation

Scarce attention capacity makes selection unavoidable. Selection occurs before many explicit decisions because only a subset of available objects can enter sustained processing. Attention allocation therefore concerns the distribution of notice, processing depth, sequence, recurrence, and response among competing claims, persons, risks, opportunities, and questions.

Allocation can be deliberate. A research funder chooses priority areas; a regulator schedules inspections; a hospital triages cases; an editorial board allocates review capacity; a firm chooses which anomalies receive engineering attention. Allocation can also emerge through routines, inherited categories, spatial organization, social networks, media dynamics, or technical interfaces. What appears as spontaneous salience may therefore contain institutional history.

Definition 17.54 (Attention-allocation profile). An *attention-allocation profile*

records the objects eligible for consideration, the receiving positions, the rules or mechanisms that order and filter them, the depth and duration of attention assigned, the sequence and recurrence of processing, the associated resource commitments, the displaced alternatives, and the pathways through which priorities can change.

The profile makes opportunity cost visible. Allocating attention to one problem can defer another even when both are important. A decision system can therefore exhibit scarcity through queues and delay rather than explicit rejection. Delay can itself become consequential when evidence decays, harms compound, opportunities close, or affected positions cannot survive the waiting period. Attention allocation consequently has a temporal incidence as well as a distributional incidence.

Allocation also influences what becomes knowable later. Research attention can generate measurements, datasets, methods, and specialist communities around selected problems. Regulatory attention can produce inspections and records that make one risk more legible than another. Repeated organizational attention can stabilize categories and routines. Neglected domains can remain poorly represented partly because the evidence required to establish their importance was never produced. Attention allocation can therefore enter a recursive relation with evidence production.

Proposition 17.55 (Attention-allocation recursion). *Attention allocation can be recursively generative when present prioritization changes the evidence, expertise, infrastructure, categories, or institutional capacities through which later attention priorities are formed.*

Proposition 17.55 does not imply that every priority becomes self-reinforcing. Attention can reveal that an object is less important than expected, generate evidence supporting deprioritization, or create infrastructure that lowers future attention costs. The proposition identifies the possibility that attention allocation changes its own future conditions. This is one reason why temporary priorities, emergency agendas, or funding initiatives can have effects beyond their formal duration.

The allocation problem also resists a universal optimization rule. Some attention must be concentrated to achieve depth; some should remain distributed to preserve anomaly detection and local knowledge; some should be protected over long horizons even when immediate signals are weak. The appropriate allocation depends on the object, uncertainty, stakes, temporal dynamics, reversibility, affected positions, and the institutional cost of missing weak signals.

17.4.3 Institutional Attention

Individual attention is only one component of the epistemic economy. Institutions can preserve, accumulate, distribute, and redirect attention through roles, routines, records, queues, schedules, specialized units, reporting requirements, review procedures, and memory systems. A university, regulator, court, firm, hospital, archive, or research institute can sustain attention to objects that no single member could continuously monitor across the institution's lifespan.

Institutional attention therefore differs from the sum of individual cognition. A risk can remain institutionally visible through a dashboard, recurring audit, statutory reporting obligation, standing committee, or archival record even as personnel

change. Conversely, many individuals can know about a problem while the institution lacks a pathway for the issue to enter an agenda, obtain resources, or trigger review. The distinction between distributed awareness and institutional uptake is economically significant.

Definition 17.56 (Institutional-attention architecture). *An institutional-attention architecture is the organized configuration of roles, routines, agendas, queues, records, metrics, review cycles, escalation pathways, staff capacities, and memory mechanisms through which an institution selects, sustains, transfers, and revises attention across time.*

The architecture can support continuity. Long-horizon scientific observation, infrastructure maintenance, environmental monitoring, patient follow-up, archival stewardship, and regulatory supervision often require attention that persists beyond individual tenure. Institutional memory can prevent the repeated rediscovery of the same problem and can preserve weak signals until their significance becomes clearer.

The same architecture can produce blind spots. Standardized forms can exclude observations that do not fit existing categories. Performance metrics can redirect effort toward what is counted. Recurrent agendas can crowd out emerging problems. Specialized departments can protect expertise while fragmenting responsibility across interfaces. Institutional attention therefore has both stabilizing and selective effects.

Proposition 17.57 (Institutional-attention persistence). *Institutional attention can persist independently of the continuous attention of particular individuals when records, mandates, routines, roles, or review mechanisms preserve an object's eligibility for future processing and response.*

Proposition 17.57 explains why epistemic infrastructure matters. A preserved claim or anomaly can re-enter attention after a personnel change or after new evidence appears. The proposition also exposes a complementary risk: if the preservation infrastructure omits an object, later institutions may interpret the absence of records as absence of prior significance. Attention and preservation therefore become linked, anticipating Sections 17.11 and 17.13.

Institutional attention is also costly. Monitoring systems, reporting duties, meetings, review panels, documentation, and escalation procedures consume staff time and administrative resources. Chapter 11 already treated monitoring burden as a methodological object. The present chapter adds the epistemic-economic perspective: institutions must allocate capacity between observing the field, interpreting observations, acting on them, and maintaining the systems that make observation possible.

17.4.4 Algorithmic Attention

Digital epistemic environments increasingly use computational systems to rank, filter, recommend, summarize, cluster, flag, or suppress candidate objects before human or institutional attention is applied. The phrase *algorithmic attention* is used here for this mediation of visibility and processing priority. It does not refer to a claim that computational systems possess human attention in a phenomenological sense.

Algorithmic mediation can expand effective attention capacity. Search engines reduce the cost of locating relevant documents. Recommender systems can surface specialized materials that would otherwise remain obscure. Anomaly-detection systems can monitor streams too large for continuous human inspection. Summarization systems can compress large documents into candidate focal points. Routing systems can assign cases to specialized reviewers. These capacities can reduce some attention bottlenecks while introducing new selection mechanisms.

Definition 17.58 (Algorithmic attention mediation). *Algorithmic attention mediation* is the use of computational rules, models, or procedures to alter the visibility, ranking, sequencing, summarization, routing, persistence, or notification status of candidate epistemic objects before or during human or institutional processing.

Definition 17.58 keeps the object at the interface between algorithmic selection and consequential attention. The economic questions concern objectives, data, update rules, error costs, override pathways, affected positions, and feedback. A ranking can be useful while still changing the incentives of ranked actors. Espeland and Sauder's analysis of ranking reactivity provides an institutional precedent: public measures can alter behavior and expectations in the environments they describe (Espeland and Sauder 2007). Algorithmic rankings can create analogous feedback when visibility affects later popularity, investment, demand, contribution, or data generation.

Algorithmic selection can also make attention allocation less legible. A user may know that a feed is ranked without knowing which features determine exposure. A regulator can receive a risk score without observing the cases filtered out. A manager can rely on exception alerts without understanding the false-negative distribution. The relevant governance problem therefore includes the unobserved candidate set as well as the visible output.

Proposition 17.59 (Algorithmic visibility–importance non-equivalence). *Algorithmically increased visibility is an insufficient standalone indicator of epistemic quality, economic importance, or normative priority because ranking and filtering reflect specified objectives, data, model structure, interface design, and feedback conditions.*

The proposition preserves the possibility that algorithmic mediation is highly useful. It simply prevents visibility from becoming a proxy for importance without additional justification. The same caution applies in reverse: low algorithmic visibility does not establish irrelevance. Attention governance therefore requires mechanisms for anomaly discovery, alternative retrieval, audit, override, and periodic reconsideration where the consequences justify them.

17.4.5 Attention Capture

Attention allocation can become strategically consequential when actors design mechanisms to obtain, retain, or repeatedly redirect scarce attention. Advertising, notifications, interface design, reputational signals, political communication, academic prestige, urgency cues, platform incentives, and repeated exposure can all affect whether an object remains within a recipient's attention field. GRE uses *attention capture* as a descriptive economic category for sufficiently persistent conditioning of attention, while leaving questions of manipulation, deception, legitimacy, or injustice to additional analysis.

Definition 17.60 (Attention-capture profile). An *attention-capture profile* records the actor or mechanism seeking sustained attention, the receiving position, the salience or retention mechanisms, the duration and recurrence of attention, the available alternatives and switching conditions, the attention displaced, the relevant incentives, and the economic consequences generated by continued exposure or engagement.

The profile distinguishes ordinary attraction from durable conditioning. A compelling scientific result can attract attention because it appears important. A product can attract attention because consumers value it. These cases do not require the stronger conclusion that attention has been captured in a problematic sense. The analytical category becomes more useful when recurrent mechanisms systematically retain or redirect attention in ways that materially affect competing uses of scarce attention capacity.

Capture can operate through different mechanisms. Salience can make one signal difficult to ignore. Repetition can increase familiarity. Notifications can interrupt competing activity. Queue position can make one task recurrently first. Social proof can direct attention toward what others have already noticed. Lock-in can make switching to alternative information environments costly. Institutional authority can require attention through mandatory reporting or review. These mechanisms differ in voluntariness, reversibility, transparency, and consequence.

Proposition 17.61 (Attention capture–intent non-equivalence). A *recurrent mechanism can capture or retain attention as an economic effect without establishing that the resulting attention pattern was intentionally designed, manipulative, or normatively objectionable*.

Proposition 17.61 mirrors the chapter’s earlier restraint concerning manufactured vulnerability and historical processes. Emergent popularity loops, institutional routines, or inherited interface designs can produce durable attention concentration without a single actor intending the final pattern. Intent remains relevant where present, but it should not be inferred from the distribution alone.

Attention capture also has generative consequences. Sustained attention can build familiarity, expertise, reputational capital, data, network effects, and institutional memory around selected objects. Competing objects can lose the opportunity to generate comparable evidence or recognition. Capture therefore can shape future attention conditions, even when the initial advantage was small.

17.4.6 Unequal Visibility

Attention becomes distributive when positions, claims, risks, products, questions, and communities differ systematically in their probability of being noticed and in the depth of processing they receive. GRE uses *visibility* for the practical availability of an object to relevant attention pathways. Visibility is narrower than social recognition and broader than physical observability: an object can exist, be technically recorded, and remain institutionally peripheral.

Definition 17.62 (Visibility-distribution profile). A *visibility-distribution profile* records which epistemic objects, positions, claims, risks, and possibilities become practically available to specified audiences or institutions; the channels and filters

through which they become visible; the depth, duration, and recurrence of that visibility; and the mechanisms producing persistent visibility differences.

Visibility can differ because of language, network position, institutional prestige, geography, interface design, data availability, category fit, publication venue, search indexing, marketing resources, professional standing, or the ease with which an effect can be quantified. Some differences can be functionally justified. A specialist journal need not give equal visibility to every claim. A safety system can legitimately prioritize high-severity alerts. A scientific review can weight evidence quality. The analytical question concerns the mechanism and consequence of unequal visibility rather than equality of exposure as a universal objective.

Unequal visibility can also reproduce itself. Highly visible work is more likely to be read, cited, funded, discussed, and incorporated into training materials, generating additional traces that support later visibility. Products with high visibility can generate sales and reviews that reinforce ranking. Institutions with established reputations can attract talent and funding that further increase their epistemic output. These loops can be productive when they reward quality, and they can preserve historical advantage or obscure emerging alternatives when feedback becomes detached from current quality.

Proposition 17.63 (Visibility–standing non-equivalence). *Unequal visibility does not by itself establish unequal epistemic standing, economic power, or injustice, although persistent visibility differences can contribute to each when they are converted through consequential institutional or economic mechanisms.*

Proposition 17.63 preserves the chapter’s mechanism-based discipline. A rarely visible claim can possess strong evidential standing. A highly visible person can have little formal authority. The relevant downstream effects must be traced through access, recognition, demand, funding, employment, classification, policy, reputation, or other consequential relations.

The distribution of visibility also influences whose absence becomes perceptible. If a position is rarely represented in records, data, deliberation, or public communication, later observers may struggle to distinguish true absence from representational omission. This links attention to epistemic justice and future re-recognizability, themes developed more fully in Sections 17.12 and 17.13.

17.4.7 Attention and Power

Chapter 16 established that attention can become power when control over visibility or institutional reception materially conditions another position’s opportunities or trajectories. The present subsection specializes that mechanism within the epistemic economy. The relevant object is not simply possessing more attention, but holding a position capable of conditioning what others notice, what becomes institutionally processable, or which claims receive scarce reception capacity.

Editors, funders, platforms, professional associations, managers, regulators, search systems, curators, and institutional gatekeepers can all influence attention allocation. Their roles differ substantially. An editor controls publication access within a defined venue. A funder influences which inquiries can acquire resources.

A search or recommendation intermediary influences discoverability. A manager allocates organizational attention. A regulator can require reporting or investigation. These positions become power-bearing only where the attention mechanism materially conditions another position's access, standing, demand, resource allocation, action, or feasible future.

Definition 17.64 (Attention power). *Attention power* is the practically consequential capacity of a position, relation, institution, or infrastructure to condition the visibility, priority, duration, or institutional reception of epistemic objects in ways that materially alter another position's access, standing, opportunities, burdens, or feasible trajectories.

The definition is narrower than influence in general. Persuasion based on reasons can affect attention without establishing a durable power relation. A famous scientist can attract notice without controlling the allocation architecture. A platform can possess substantial attention power even if it does not determine users' beliefs, because visibility itself can affect demand, discovery, reputation, and opportunity.

Proposition 17.65 (Attention–power conversion). *Attention asymmetry constitutes economic power when a traceable mechanism converts differential control over visibility, priority, or reception into consequential conditioning of another position's economic or epistemic possibilities.*

Proposition 17.65 aligns attention with the mechanism-based power theory of Chapter 16. It also preserves productive specialization. Curators, reviewers, editors, search systems, and expert bodies can improve coordination by concentrating scarce evaluative capacity. The power question concerns how consequential conditioning is authorized, reviewed, contested, and distributed, not whether selection exists at all.

Attention power can be reciprocal and multilevel. A platform can direct user attention while user engagement data shapes platform rankings. A regulator can require firms to report particular risks while firms influence which operational realities regulators can observe. Researchers depend on journals and funders, while those institutions depend on researchers for expertise, prestige, and evaluative labor. Attention-power analysis should therefore reconstruct the relation rather than assume one-directional control.

17.4.8 Attention Governance

Once attention is treated as scarce, allocated, institutionally structured, and potentially power-bearing, its governance becomes a substantive economic problem. Attention governance concerns how systems prioritize, protect, distribute, rotate, escalate, preserve, audit, and revise attention under finite capacity. Its objective is to organize consequential selectivity so that priorities remain sufficiently capable, traceable, contestable, and revisable for the relevant stakes and horizon. Finite attention capacity makes selective processing a persistent design condition across many epistemic-economic fields.

Definition 17.66 (Attention-governance architecture). An *attention-governance architecture* is the organized configuration of prioritization rules, protected attention

commitments, queues, filters, rotation mechanisms, escalation pathways, anomaly channels, review procedures, algorithmic mediation, workload limits, and revision rules through which scarce attention is allocated and reallocated across a specified epistemic-economic field.

Several governance functions can be separated. *Prioritization* identifies what deserves immediate or sustained processing. *Protection* reserves capacity for objects likely to be crowded out by short-horizon pressures, such as maintenance, long-term research, archival work, or low-frequency risks. *Rotation* prevents permanent monopoly of attention by recurring objects where periodic reconsideration is appropriate. *Escalation* allows anomalies or weak signals to bypass ordinary queues when defined conditions are met. *Audit* examines whether attention intermediaries systematically omit relevant classes of objects. *Revision* updates the allocation architecture when evidence, capacities, objectives, or affected positions change.

Attention governance must also protect against overload created by governance itself. Reporting duties, dashboards, indicators, consultation requirements, reviews, alerts, and audit procedures can each be defensible while collectively exceeding institutional processing capacity. A system can therefore increase nominal oversight while reducing effective attention to any individual signal.

Proposition 17.67 (Attention-governance reflexivity). *Attention governance is reflexive because monitoring, prioritization, reporting, auditing, and review mechanisms consume the same finite attention capacities whose allocation they seek to improve and can thereby alter the scarcity profile they govern.*

The proposition implies that governance architecture should include its own burden. More indicators can improve observability while creating indicator congestion. More consultation can broaden participation while overwhelming participants with procedural demands. More alerts can improve sensitivity while producing alert fatigue. The appropriate design therefore depends on the marginal epistemic value and burden of additional attention mechanisms.

A second governance problem concerns protected pluralism. Immediate salience should not automatically displace slow processes; dominant institutions should not automatically absorb all field attention; and long-horizon or minority inquiry may require protected capacity precisely because its value cannot be established through current popularity. At the same time, protection can become insulation from review. Attention governance therefore needs both continuity and challenge.

Proposition 17.68 (Attention-governance pluralism). *Adequate attention-allocation rules are field-dependent where epistemic-economic objects differ in urgency, uncertainty, reversibility, temporal horizon, affected positions, evidential maturity, and generative consequence; governance should therefore make the applicable selection rule and its scope explicit.*

Proposition 17.68 closes the section without converting attention into a universal master resource. Some fields require rapid triage; others require slow sustained inquiry. Some require concentrated expertise; others benefit from distributed observation. Some risks justify persistent monitoring; others justify periodic review. The economic task is to reconstruct the relevant attention architecture and the consequences of its selectivity.

Attention also prepares the next analytical step. Selection among already visible objects does not explain how new questions become salient, why a surprising relation attracts sustained inquiry, or how an initially weak signal becomes a motivating problem. Those processes involve encounter, salience, wonder, curiosity, and question formation. Section 17.5 therefore turns from the allocation of scarce attention to the generative formation of inquiry itself.

17.5 Curiosity and Question Formation

Section 17.4 treated attention as an economic problem of selective reception and processing among objects that have already become sufficiently available to compete for notice. The present section examines an earlier generative layer: the formation of inquiry itself. Its role is to reconstruct how encounters can become salient, how salience can develop into wonder or curiosity, how curiosity can acquire an articulated question, and how a question can receive enough temporal, material, institutional, and relational support to become sustained inquiry. The objective is economic, using the earlier genealogical and methodological treatments as background. Chapter 2 reconstructed intellectual traditions of wonder, curiosity, and question formation; Chapter 6 located encounter, salience, judgment, and orientation within research praxis; and Chapter 8 specified the generative research question. The present discussion asks how the capacities and relations involved in those processes are distributed, supported, crowded out, and reproduced within an epistemic economy.

The analysis therefore treats inquiry formation as a historically situated sequence of possible relations with branching, recurrence, discontinuity, and alternative entry points. An encounter can remain unnoticed. Salience can fade without producing wonder. Wonder can remain contemplative. Curiosity can be satisfied quickly, redirected, or suppressed. A question can arise from obligation, practical difficulty, collective contestation, or inherited disciplinary work without a prior experience readily described as curiosity. Sustained inquiry can also outlive the curiosity that initiated it. The analytical value of the sequence lies in separating distinct conditions and bottlenecks whose economic organization can differ.

Definition 17.69 (Inquiry-formation architecture). An *inquiry-formation architecture* is the configuration of encounters, salience mechanisms, epistemic dispositions, conceptual and linguistic resources, temporal horizons, material and institutional supports, social relations, evaluative practices, and continuation mechanisms through which a possible unknown can become an articulated and sustained object of inquiry.

Definition 17.69 shifts the economic question away from a presumed stock of curiosity. Curiosity can depend on what a position is able to encounter, what it has learned to recognize as surprising, which concepts make a gap intelligible, whether sufficient time exists to remain with uncertainty, and whether institutions permit a question to persist before its value is established. Unequal inquiry formation can therefore arise even where formal access to information is similar.

Table 17.5 summarizes the analytical distinctions developed below.

The rows in Table 17.5 can occur in several orders and can feed back upon one an-

Table 17.5: Generative dimensions of curiosity and question formation in an epistemic economy.

Dimension	Generative function	Economic conditions and possible bottlenecks
Encounter	Makes an object, trace, difference, or relation available to possible inquiry	Access, mobility, instruments, archives, networks, exposure, observation time, and record preservation
Salience	Gives an encounter sufficient prominence for further processing	Attention capacity, contrast, repetition, ranking, institutional agendas, social recognition, and protected anomaly channels
Wonder	Suspends habitual intelligibility and keeps a perplexity open	Time, security, intellectual permission, conceptual plurality, tolerance of uncertainty, and cultural or educational formation
Curiosity	Motivates further engagement with an intelligible unknown	Prior knowledge, perceived knowledge gaps, exploratory capacity, affective engagement, incentives, and freedom to investigate
Question formation	Converts indeterminacy into an addressable epistemic object	Language, concepts, methods, problem-framing skills, interlocutors, disciplinary resources, and contestability
Long-horizon inquiry	Sustains a question across delayed feedback and uncertain payoff	Funding duration, employment security, institutional memory, archives, infrastructure, patient evaluation, and continuity of community
Inquiry beyond immediate utility	Preserves exploration whose future use or significance is weakly predictable	Slack, public or philanthropic support, academic autonomy, cross-subsidy, option value, and plural valuation criteria
Relational sources	Generates or redirects curiosity through interaction and participation	Teachers, peers, communities, affected groups, objects, environments, institutions, and human–AI relations

other. A formed question changes what later encounters become visible. Sustained inquiry develops expertise that creates new knowledge gaps. Social relations can generate curiosity before an individual can name the object of inquiry. Institutional resources can preserve a weakly salient question until later evidence makes it important. The relevant economic object is therefore a generative configuration capable of opening, narrowing, sustaining, or closing epistemic possibility.

Proposition 17.70 (Inquiry-stage non-equivalence). *Encounter, salience, wonder, curiosity, question formation, and sustained inquiry should be treated as analytically distinct where their enabling conditions, temporal persistence, resource requirements, and consequences differ, even when several occur within one connected episode of inquiry.*

Proposition 17.70 prevents answer-centered accounts of knowledge production from compressing the prehistory of inquiry into a single preference or demand for information. Each stage can have a different scarcity profile and a different distribution across persons, organizations, disciplines, and societies.

17.5.1 Encounter

Encounter is the point at which a possible object of inquiry becomes available to a position capable of registering it. Chapter 6 developed encounter as a component of research praxis, including encounters with existence, contingency, difference,

anomaly, repetition, and unexpected relation. The economic problem begins one level earlier than formal research design: the opportunity to encounter is itself distributed.

Access to environments, archives, instruments, languages, communities, datasets, professional networks, and technical systems changes what can enter an epistemic field. A marine biologist with ship time can encounter phenomena unavailable to a scholar confined to published reports. A historian with archival access can encounter traces hidden from researchers whose access is limited by geography, language, classification, cost, or legal restriction. A worker situated inside an organization can encounter recurrent operational failures invisible to senior management. A community can possess lived or practical knowledge that remains weakly connected to institutions with resources for formal investigation.

Definition 17.71 (Encounter opportunity). An *encounter opportunity* is a practically accessible relation through which a position can become exposed to an object, event, trace, difference, absence, recurrence, or relation in a form capable of affecting subsequent inquiry.

Encounter opportunity is broader than information access. A searchable database can provide extensive symbolic access while offering little contact with the conditions under which its categories were produced. Field participation can reveal tacit practices while limiting comparative range. Instruments extend encounter into scales inaccessible to unaided perception while embedding calibration, sampling, and classification decisions. Economic organization therefore affects both the quantity and the form of possible encounter.

The distribution of encounter opportunities can create epistemic path dependence. Early exposure to a language, discipline, community, landscape, instrument, or archive can alter later competence and therefore alter the set of encounters that become possible in the future. Educational travel, laboratory apprenticeship, interdisciplinary collaboration, public libraries, open datasets, and accessible cultural institutions can enlarge encounter spaces. Segregation, cost barriers, institutional closure, restrictive licensing, inaccessible interfaces, and precarious schedules can narrow them.

Encounter also requires preservability. An unusual observation can disappear before it becomes salient if the surrounding system lacks records, notebooks, logs, archives, memory practices, or channels for reporting weak signals. The economic value of recording capacity lies partly in preserving encounters whose significance is initially unknown. This creates an intertemporal problem: storage, documentation, and provenance incur present cost while their later epistemic value can remain uncertain.

Proposition 17.72 (Encounter-distribution effect). *Differences in access, mobility, instruments, recording capacity, institutional position, and relational participation can alter the distribution of future questions by changing which encounters become available for later salience and interpretation.*

Proposition 17.72 gives encounter a specifically economic significance. Resource allocation can influence inquiry before any research question exists. Funding only articulated proposals therefore observes a later stage of knowledge production and can

miss the infrastructures through which articulable questions first become possible.

17.5.2 Salience

Encounter creates availability; salience gives some available objects sufficient prominence to affect further processing. Chapter 6 separated research salience from significance, and Section 17.4 analyzed the allocation of attention among competing objects. The present subsection focuses on their generative interface: an object can enter inquiry because a contrast, anomaly, recurrence, absence, or unexpected relation becomes prominent enough to resist routine dismissal.

Salience depends partly on background expectations. A deviation is visible only relative to some practical or conceptual regularity. Expertise can therefore increase sensitivity to subtle anomalies while simultaneously producing habituation to other features. Institutional classification can make one dimension continuously visible and leave another weakly represented. Algorithmic systems can amplify frequently engaged objects while obscuring low-frequency signals. Economic organization participates in salience by shaping expectations, measurement regimes, rankings, displays, and opportunities for comparison.

A useful distinction concerns *experienced salience* and *institutional salience*. Experienced salience occurs when a person or group finds an object prominent. Institutional salience occurs when routines, indicators, agendas, alerts, reporting categories, or review processes repeatedly bring an object into organizational attention. The two can diverge. Frontline workers can experience a recurring anomaly that never enters formal reporting, while a metric can remain institutionally salient despite weak relevance to local practice.

Definition 17.73 (Inquiry salience). *Inquiry salience* is the relational prominence through which an encountered object, difference, absence, or pattern acquires sufficient attention potential to motivate further interpretation, comparison, preservation, or questioning within a specified epistemic setting.

Inquiry salience remains weaker than established importance. Bordalo, Gennaioli, and Shleifer's economic salience model shows one way in which context-dependent prominence can affect choice; the present use has a broader object and concerns the preconditions of inquiry in addition to decision contexts (Bordalo et al. 2012). The distinction matters because systems optimized for present engagement can amplify what stands out without improving the formation of consequential questions.

Economic design can therefore protect forms of salience that market or institutional demand would otherwise suppress. Anomaly channels, exploratory seminars, field notes, maintenance logs, complaint systems, cross-disciplinary encounters, protected observation time, and rotation across roles can expose differences that standardized workflows absorb. Such arrangements do not determine which anomalies are significant. They preserve the possibility that weakly established signals can receive enough attention for significance to be investigated.

Proposition 17.74 (Salience-significance separation). *Economic arrangements that increase the salience of an epistemic object can enlarge its probability of entering inquiry while leaving its epistemic, practical, or normative significance unresolved.*

This separation is important for later governance. A system can rationally reserve small amounts of attention for anomalies without treating every anomaly as evidence of a major problem. The economic problem is to preserve a channel from weak signal to inspectable question at a cost compatible with finite attention capacity.

17.5.3 Wonder

Wonder names one possible mode through which salience becomes a more durable disturbance of habitual intelligibility. Plato's *Theaetetus* and Aristotle's *Metaphysics* provide classical precedents for connecting wonder with the beginning of philosophical inquiry (Plato 1921; Aristotle 2016). Chapter 2 treated these passages genealogically. The economic question concerns the conditions under which a perplexity can remain open long enough to become intellectually productive.

Wonder often requires temporal slack. Immediate task pressure encourages rapid classification: the unfamiliar object is assigned to an existing category, the anomaly is treated as noise, and the interruption is closed. Such closure can be appropriate where urgent action is required. Other settings benefit from preserving a period in which the object remains insufficiently assimilated. Time for reading, reflection, observation, conversation, exploratory calculation, or repeated encounter can allow a perplexity to acquire structure.

Material security can influence this capacity. Precarity does not eliminate curiosity or wonder, and historically important inquiry has emerged under severe constraint. The narrower claim is that persistent demands for immediate production can reduce discretionary time and increase the cost of remaining with questions whose payoff is delayed or unclear. Institutions with sabbaticals, research leave, protected study time, fellowships, residencies, libraries, laboratories, and long-duration appointments create different opportunity structures for sustained perplexity than institutions organized almost entirely around short-cycle deliverables.

Wonder also depends on intellectual permission. Educational and professional cultures vary in how they respond when someone asks why a familiar practice exists, notices a category mismatch, or questions an inherited premise. Some environments reward rapid answerability and conformity to established problem sets. Others provide legitimate space for uncertainty, exploratory conversation, and provisional questions. Dewey's treatment of reflective thought connects curiosity and perplexity with educational conditions capable of cultivating inquiry (Dewey 1910). GRE reads this as an economic-organizational issue as well: schedules, evaluation rules, authority relations, and resource commitments can influence whether perplexity is developed or prematurely closed.

Definition 17.75 (Protected perplexity). *Protected perplexity* is a temporally and institutionally supported interval in which an encountered difficulty, anomaly, or unfamiliar relation can remain open to observation and interpretation before an immediate classificatory or utilitarian resolution is required.

Protected perplexity should not be romanticized. Delayed closure can impose costs, and some decisions require timely action under uncertainty. Its value depends on stakes, reversibility, available capacity, and the expected consequence of premature simplification. The concept identifies a resource condition for some forms of inquiry

and leaves the appropriate duration dependent on the stakes and setting.

Proposition 17.76 (Perplexity-support condition). *Where inquiry requires an initially ambiguous object to remain open across repeated observation or interpretation, temporal slack, material support, and permission to suspend premature closure can increase the practical possibility that salience develops into a structured epistemic problem.*

This proposition connects wonder to the later problem of long-horizon inquiry. The relevant economic good is partly the capacity to defer immediate closure while preserving accountability for the resources used during that interval.

17.5.4 Curiosity

Curiosity gives the open unknown a motivational relation to further exploration. Psychological research has proposed several mechanisms with differing objects and scopes. Berlyne connected exploratory behavior with novelty, complexity, uncertainty, and conflict; Loewenstein developed an information-gap account in which awareness of a gap in knowledge can create a motivation to obtain missing information; and Litman, Hutchins, and Russon distinguished forms of epistemic curiosity associated with different knowledge states and affective orientations (Berlyne 1954; Loewenstein 1994; Litman et al. 2005). These theories differ in scope and should remain distinct. For GRE, their shared relevance lies in showing that curiosity depends on relations among prior knowledge, perceived uncertainty, affect, and anticipated understanding.

This dependence has economic implications. A person may need enough prior knowledge to perceive that a gap exists. Education can therefore generate new ignorance in the productive sense of making previously invisible unknowns intelligible. Access to examples, instruments, mentors, and contrasting cases can transform an undifferentiated absence of knowledge into a specific object worth exploring. Conversely, informational abundance can suppress curiosity when ready-made summaries create an impression of closure before the underlying gap has been recognized.

Curiosity also has costs. Exploration consumes time, cognitive effort, materials, compute, travel, experimental capacity, and often the attention of other people. In organizations, curiosity can compete with production schedules and standardized responsibilities. In education, open-ended exploration can compete with coverage requirements and assessment preparation. In research, exploratory work can be difficult to justify when evaluation systems demand predictable outputs within short cycles. The economic problem concerns which forms of exploratory capacity are supported, by whom, for how long, and under which accountability arrangements.

Definition 17.77 (Curiosity opportunity structure). *A curiosity opportunity structure is the configuration of prior knowledge, accessible unknowns, time, material resources, social permission, exploratory tools, evaluative rules, and continuation pathways that affects whether an epistemic interest can develop into further investigation.*

Definition 17.77 preserves agency while avoiding an individualistic treatment of curiosity. Curiosity remains experienced by persons and possibly organized

by groups, yet its practical expression depends on surrounding relations. A child with a question needs time, language, materials, and responsive interlocutors. A scientist needs access to methods, colleagues, instruments, and funding. A citizen investigating a public problem may need records, legal access, statistical literacy, and organizations capable of sustaining collective inquiry.

Curiosity can also be cultivated over time. Hidi and Renninger distinguish phases through which situational interest can be triggered, maintained, and develop into more durable individual interest (Hidi and Renninger 2006). Their educational model should not be converted directly into an economic law. It nevertheless supports an important temporal point: sustained epistemic orientation can have a developmental history. Short encounters can matter because institutions and relations provide repeated opportunities for engagement.

Proposition 17.78 (Curiosity-capacity interaction). *The practical generativity of curiosity depends jointly on motivational orientation and the capacities required to investigate the relevant unknown; changes in education, time, tools, access, or social support can therefore alter what curiosity is able to generate without mechanically determining what a person will find interesting.*

The proposition distinguishes curiosity from executable inquiry. Desire to know does not itself supply the capacities needed to discover, test, interpret, or communicate. Epistemic economies distribute both motivations and the means through which motivations become consequential.

17.5.5 Question Formation

Question formation converts an open unknown into a more addressable epistemic object. The transition can involve naming a discrepancy, specifying a target, delimiting a comparison, identifying what would count as an answer, or determining which uncertainty deserves sustained investigation. Dewey's account of reflective thought treats the transformation of a confused difficulty into a defined problem as part of inquiry itself (Dewey 1910). Creativity research similarly distinguishes problem finding from the solution of an already specified problem (Getzels and Csikszentmihalyi 1976). GRE adds an economic question: which positions possess the resources and authority required to formulate problems that institutions will recognize as actionable?

Question formation requires conceptual and linguistic resources. A person can experience difficulty without possessing terms that render the difficulty communicable. A community can recognize a recurring harm while lacking categories accepted by administrative or scientific systems. A researcher can sense that a model is inadequate while lacking a comparative case, instrument, or mathematical language that makes the discrepancy tractable. Language education, conceptual repertoires, classification systems, professional training, and interdisciplinary translation can therefore affect the space of formable questions.

The process also depends on problem-framing authority. Institutions frequently receive questions in standardized forms: grant calls, policy briefs, diagnostic categories, survey instruments, legal causes of action, audit templates, and research programmes. Standardization can make questions comparable and fundable. It can also

privilege questions already compatible with available methods, categories, or institutional jurisdictions. Epistemic-economic analysis should therefore distinguish *question formation* from *question recognition*. A question can be intelligible to an affected community while remaining illegible to the institution controlling resources for investigation.

Definition 17.79 (Question-formation capacity). *Question-formation capacity* is the practical ability of a position or collective to transform an indeterminate concern, anomaly, knowledge gap, or exploratory interest into an articulated epistemic object whose scope, terms, possible evidence, and continuation pathways are sufficiently specified for further inquiry.

Question-formation capacity does not imply that the resulting question is well posed or important. It identifies a conversion capacity. Chapter 8 later supplies a demanding specification discipline for generative research questions, while the present analysis asks what makes such specification possible before methodological refinement begins.

Question formation also allocates future resources. Once a problem is named, it can organize reading, observation, data collection, hiring, instrumentation, grant allocation, and collaboration. It can create categories that later shape what becomes visible. This makes question formation a generative economic event. The effect can be constructive when a previously diffuse problem becomes investigable; it can also narrow inquiry if the initial framing excludes relevant relations or makes alternative formulations difficult to pursue.

Proposition 17.80 (Question-formation leverage). *Question formation can have disproportionate downstream effects because an articulated problem can coordinate later attention, evidence collection, methodological choice, institutional resources, and evaluation around a particular representation of what remains unknown.*

This leverage helps explain why cheap answer generation does not remove scarcity from knowledge production. Systems capable of producing many plausible responses can increase the value of disciplined problem formation when the space of candidate questions expands faster than available capacities for investigation and validation.

17.5.6 Long-Horizon Inquiry

Some questions can be answered within short cycles; others require years or generations of observation, theoretical development, archival accumulation, infrastructure construction, longitudinal comparison, or repeated failure. Long-horizon inquiry is therefore an economic problem of continuity under delayed and uncertain feedback. The relevant scarcity concerns the capacity to keep a question alive while personnel, institutions, technologies, and evaluative priorities change.

Temporal continuity requires more than long grants. Archives preserve earlier observations; standards make measurements comparable; laboratories and observatories maintain instruments; professional communities transmit tacit practices; journals and repositories maintain accessible records; educational institutions reproduce expertise; and organizations carry unfinished questions across personnel turnover. Long-horizon inquiry is consequently distributed across infrastructures and genera-

tions.

Definition 17.81 (Inquiry horizon). An *inquiry horizon* is the temporal interval over which a question, evidence architecture, interpretive problem, or research programme is expected to require continuity before its principal epistemic value can be assessed with the degree of confidence appropriate to the inquiry.

Inquiry horizons can exceed contractual, electoral, product, funding, or career horizons. This mismatch creates a recurrent economic tension. A project can be valuable under a twenty-year epistemic horizon and difficult to justify within an annual output cycle. Institutions can partially bridge this mismatch through endowments, public funding, tenure-like security, long-term observatories, cohort studies, archives, infrastructure commitments, and evaluation conducted at programme as well as project level. Each arrangement has governance costs and can preserve weak programmes as well as valuable ones. Long duration therefore requires periodic review without collapsing evaluation into immediate payoff.

Sustained interest is also developmental. Hidi and Renninger's model emphasizes that maintained and well-developed interest can emerge through repeated engagement rather than appearing fully formed at the beginning (Hidi and Renninger 2006). At a collective level, a similar temporal caution is useful: durable inquiry communities can grow around questions whose importance becomes clearer through accumulated work. The analogy should remain limited because institutional programmes and psychological persons occupy different analytical levels. Its value lies in recognizing that epistemic commitment can itself be generated through history.

Long-horizon inquiry also requires succession. A question tied entirely to one person's memory can disappear when that person leaves. Documentation, shared concepts, provenance, mentoring, and accessible negative results help convert individual continuity into relational continuity. This problem anticipates Section 415 on preservation and re-epistemization, where the book will examine how future investigators can recover and reinterpret earlier epistemic work.

Proposition 17.82 (Horizon-support alignment). *Inquiry whose plausible epistemic horizon substantially exceeds the horizon of its supporting contracts, evaluation cycles, or institutional memory faces an elevated risk of discontinuation that is independent of the intrinsic quality of the underlying question.*

The proposition does not establish which long projects deserve continuation. It identifies a structural source of selection. Short-horizon institutions can systematically underproduce questions whose value becomes legible only through long accumulation.

17.5.7 Inquiry beyond Immediate Utility

Epistemic economies also face questions whose future use, significance, or application is weakly predictable at the time of inquiry. Aristotle's classical account associates philosophical wonder with knowledge pursued beyond immediate practical utility, while Veblen's discussion of *idle curiosity* treats non-utilitarian inquiry as capable of producing knowledge that can later acquire technological relevance (Aristotle 2016; Veblen 1914). These traditions differ substantially, yet both make visible a

temporal distinction between the motive for inquiry and possible later use.

GRE can restate this problem without assuming that curiosity-driven inquiry is intrinsically superior. Inquiry beyond immediate utility carries opportunity costs, and societies face legitimate distributive questions about the allocation of scarce research resources. The economic issue is that present utility is an incomplete predictor of future generativity where knowledge can be recombined, reinterpreted, or connected to later problems that do not yet exist.

Definition 17.83 (Open-use inquiry). *Open-use inquiry* is inquiry whose continuation is justified partly by epistemic significance, exploratory value, capability formation, or future option value while specific downstream applications remain substantially unresolved at the time resources are committed.

The term *open-use* avoids treating the activity as useless. Some inquiries produce conceptual tools, measurement methods, archives, trained communities, datasets, or unexpected relations even when no immediate application is identified. Their economic consequence can lie in enlarging later option spaces even when a predefined output is absent. Chapter 14's account of generative value provides the broader framework for interpreting such delayed and distributed effects.

Supporting open-use inquiry requires institutions capable of tolerating uncertain conversion. Public research organizations, universities, philanthropic foundations, museums, libraries, archives, and some firms can create portfolios in which a portion of resources is allocated to questions with uncertain application. Portfolio structure matters because uncertainty at the project level can coexist with valuable diversity at the system level. Evaluation can examine epistemic quality, tractability, capability formation, novelty, preservation value, and responsible resource use without demanding a specific near-term product from every project.

The same logic applies to education. Exploratory study can generate concepts and interests whose later relevance cannot be specified in advance. Treating learning activities uniformly as investments with predetermined labor-market returns can miss effects on later question formation, judgment, interdisciplinary translation, civic participation, or capacity to recognize new problems. Such effects are difficult to measure and should not be asserted automatically, yet their possibility is economically relevant when designing educational opportunity.

Proposition 17.84 (Immediate-utility incompleteness). *Where the future recombination, application, or interpretive significance of knowledge is materially uncertain, evaluation based exclusively on presently specifiable utility can omit part of the inquiry's generative option value and can thereby narrow the future question space.*

Proposition 17.84 supplies a restrained economic reason for preserving some inquiry beyond immediate utility. It does not imply unlimited support. It implies that evaluation architectures should make their temporal assumptions explicit and distinguish absence of current application from evidence of negligible future generative value.

17.5.8 Relational Sources of Curiosity

The final analytical step treats curiosity and question formation as relationally generated. An individual can experience curiosity internally, yet the objects, concepts, contrasts, languages, standards, and opportunities through which that curiosity develops are often supplied through relations with other persons, institutions, environments, artifacts, and technologies. Inquiry formation therefore has a social and material ecology.

Teachers can expose learners to objects they would not otherwise encounter and can model how an uncertainty becomes a question. Peers can create comparison, disagreement, and reciprocal exploration. Research communities can preserve long-lived problems and provide standards through which partial progress becomes visible. Affected communities can identify practical contradictions that formal institutions have overlooked. Archives and instruments can place earlier or otherwise inaccessible traces into relation with present investigators. Objects and environments can resist expectations in ways that redirect inquiry. Human–AI interaction can rapidly generate candidate explanations, contrasts, simulations, and questions, while also creating risks of premature closure when fluent outputs are mistaken for settled understanding.

These relations can widen or narrow curiosity. Hierarchical environments can discourage questions that challenge role boundaries. Homogeneous networks can stabilize shared blind spots. Diverse communities can expose participants to unfamiliar premises while also increasing translation costs. Platforms can enlarge encounter spaces while ranking mechanisms concentrate attention around already visible objects. Funding programmes can convene new interdisciplinary relations while steering inquiry toward predeclared categories. The effect of a relation therefore depends on its structure and the capacities surrounding it.

Definition 17.85 (Relational curiosity field). A *relational curiosity field* is the historically situated configuration of persons, objects, communities, institutions, languages, infrastructures, and technological mediators whose interactions shape which unknowns become encounterable, salient, intelligible, discussable, and supportable as possible questions.

The field language is representational and does not imply a unique underlying ontology. Its purpose is to prevent inquiry formation from being assigned entirely to isolated preference. A researcher's question can have a distributed prehistory involving teachers, inherited concepts, instruments built by others, archived observations, institutional funding, social conflict, linguistic translation, and contingent encounters. This relational reconstruction preserves questions of authorship and responsibility while making the generative conditions of authorship more visible.

Institutional agenda setting provides a collective example. Scientific communities organize legitimate problems through paradigms, methods, training, and evaluative standards, while sociological research on undone science shows that potentially valuable lines of inquiry can remain unfunded, incomplete, or ignored within existing research agendas (Kuhn 1962; Frickel et al. 2010). The two literatures address different questions, yet together they support the narrower GRE claim that the distribution of inquiry cannot be inferred from the distribution of possible questions alone. Institu-

tions participate in selecting which unknowns acquire durable resources.

Proposition 17.86 (Relational generation of inquiry). *The formation of sustained inquiry can be distributed across relations that provide encounter, salience, language, conceptual resources, motivation, criticism, infrastructure, recognition, and continuation; analysis of epistemic opportunity should therefore include the relations that generate a question as well as the position that ultimately articulates it.*

Proposition 17.86 completes the section's economic argument. Inquiry has a pre-history whose stages can be unequally supported. Encounter opportunities can be scarce; salience can be institutionally filtered; perplexity can require protected time; curiosity can depend on prior knowledge and exploratory capacity; question formation can require language and recognition; long-horizon inquiry can depend on continuity infrastructures; and open-use inquiry can depend on institutions willing to carry uncertain future value. These conditions influence which unknowns become economically consequential before any answer is produced.

Curiosity and question formation also prepare the next analytical object. Once several questions become available, inquiry still requires judgments about which directions display beauty, elegance, surprise, depth, or generative promise and how such judgments are historically formed. Section 17.6 therefore examines aesthetic judgment and epistemic orientation as a further layer of selection within the epistemic economy.

17.6 Aesthetic Judgment and Epistemic Orientation

Aesthetic judgment supplies a further layer of selection within an epistemic economy. Section 17.5 examined how encounters can become salient, curious, question-forming, and supportable as sustained inquiry. The present section examines how researchers and institutions orient among questions, representations, models, conjectures, explanations, and research trajectories whose epistemic value remains incompletely known. Its objective is to identify the economic role of judgments concerning beauty, elegance, surprise, depth, and generative promise while preserving their distinction from evidential warrant, normative justification, and realized generative value. The discussion proceeds through these orienting qualities, their integration in research taste, the historical formation of that taste, and the economic conditions that shape its development and exercise. The method is interpretive and relational. Classical aesthetics, empirical aesthetics, philosophy of science, and sociology of taste provide resources for specifying the phenomenon, while GRE concentrates on the allocation, capability, institutional, and temporal consequences of aesthetic orientation.

Chapter 2 treated aesthetics as part of the intellectual genealogy that makes a generative relational account possible, and Chapter 6 located aesthetic judgment within research praxis. The economic problem developed here is narrower and more specific. Inquiry capacity is finite even when candidate questions, texts, models, and answers become abundant. Researchers therefore make consequential selections before complete epistemic justification is available. Some possibilities appear elegant, deep, surprising, beautiful, or capable of opening a wider field of inquiry; others ap-

pear technically feasible yet comparatively barren. These anticipatory judgments can influence the allocation of time, funding, collaboration, computational resources, institutional recognition, and personal persistence. They consequently belong to the epistemic economy even when their content remains partly tacit.

Definition 17.87 (Epistemic aesthetic orientation). *Epistemic aesthetic orientation* is the historically and relationally formed use of aesthetic or form-sensitive judgment to direct attention, inquiry, representation, or persistence among epistemic possibilities whose eventual evidential and generative significance remains incompletely determined.

Definition 17.87 assigns aesthetic judgment an orienting role. Beauty, elegance, surprise, and depth can influence where inquiry goes without functioning as independent proofs of truth. Their economic relevance lies partly in this interval between possible importance and established warrant, where scarce resources must often be committed under uncertainty.

17.6.1 Beauty

Beauty can enter inquiry as an experience of fittingness, coherence, proportion, richness, or compelling form. The term carries heterogeneous philosophical meanings, so GRE treats beauty here as a field-dependent family of aesthetic judgments rather than fixing a universal definition. Kant's account of judgments of taste, Hume's analysis of cultivated judgment, and Dewey's account of aesthetic experience already show distinct ways in which aesthetic appraisal can involve feeling, form, experience, comparison, and historically developed capacities (Kant 1987; Hume 1985; Dewey 1934). The present argument uses this diversity as a constraint: beauty should be treated as a family of orienting judgments whose local meaning depends on practice and field.

Within research, an experience of beauty can stabilize attention around a relation that is not yet fully understood. A proof strategy may appear beautiful because distant elements suddenly fit together. A historical interpretation may appear beautiful because heterogeneous traces become intelligible within a coherent configuration. An experiment may reveal a pattern whose regularity invites further investigation. A theoretical representation may produce a sense that several previously separate problems have acquired a common form. Such responses can motivate continued inquiry even before the relevant evidential burden has been discharged.

This orienting function is economically significant because persistence is costly. Sustained work consumes time, training, access to instruments, data, computation, mentorship, and institutional patience. A judgment that an unresolved relation possesses aesthetic significance can therefore affect whether these resources continue to be committed. The judgment can also influence collective attention when compelling representations circulate through seminars, publications, visualizations, demonstrations, or teaching.

Aesthetic attraction carries corresponding risks. Beautiful form can create premature confidence, especially when coherence in representation is mistaken for adequacy to the represented object. A highly symmetric model can underrepresent asymmetry; a clean narrative can suppress irregular evidence; a compelling visualization can obscure measurement choices. The relevant GRE distinction is between

orientation by beauty and warrant through evidence. The first can be economically consequential while remaining open to correction by the second.

Proposition 17.88 (Aesthetic orientation under incomplete warrant). *Where epistemic possibilities cannot be fully evaluated before resources are committed, aesthetic judgment can serve as one source of provisional orientation, provided that later evidential and normative assessment retains the capacity to revise the resulting allocation.*

Proposition 17.88 gives aesthetic judgment a bounded role. It can support exploration where explicit criteria remain incomplete. Its value depends partly on whether the surrounding epistemic system preserves correction, comparison, and exit from aesthetically attractive but poorly supported trajectories.

17.6.2 Elegance

Elegance is a more specific orienting quality. In research practice it commonly refers to economy of means, structural clarity, compression, unification, or the achievement of substantial explanatory or inferential work through a comparatively spare construction. McAllister's historical analysis of scientific aesthetics is especially relevant because it treats simplicity and related aesthetic criteria as historically variable components of scientific evaluation rather than timeless guarantees of truth (McAllister 1996).

Elegance can possess genuine epistemic utility. A concise representation can expose relations that remain difficult to perceive in a more cumbersome form. Compression can lower cognitive and communicative costs. A unifying model can make comparison across cases easier. A proof with a small number of powerful steps can reveal which structures are doing the essential work. An elegant research design can reduce unnecessary measurement or intervention while preserving inferential leverage. These properties help explain why elegance can attract scarce attention and become a criterion in expert judgment.

The economic effects extend beyond individual cognition. Elegant formulations are often easier to teach, transmit, cite, standardize, implement, and incorporate into institutional repertoires. They can therefore have lower reproduction costs than equally accurate but more cumbersome alternatives. Once embedded in textbooks, software, professional routines, or canonical examples, an elegant representation can accumulate durable attention advantages.

Elegance can also become a source of selection bias. Phenomena whose causal or relational structure is heterogeneous, historically contingent, multiscale, or resistant to compression can appear aesthetically inferior to representations that simplify them. A discipline that rewards elegance strongly may therefore allocate disproportionate resources toward problems that admit elegant representation. The result can be an epistemic portfolio shaped partly by representational tractability.

Empirical aesthetics provides a limited supporting analogy. Processing fluency can influence aesthetic pleasure under some conditions, while expertise and cognitive mastering can alter aesthetic evaluation (Reber et al. 2004; Leder et al. 2004). Their relevance here is limited to the formation of aesthetic experience: ease, familiarity, and learned competence can contribute to experiences that are subsequently

interpreted as elegant, while scientific validity remains governed by the evidential standards appropriate to the inquiry. Reflexive inquiry should therefore distinguish structural economy in the object or representation from the ease produced by prior training.

Elegance is thus economically double-sided. It can reduce cognitive and transmission costs while also steering inquiry toward forms compatible with prevailing repertoires. An epistemic economy benefits from elegance when compression improves intelligibility and generativity, while retaining institutional space for objects whose significance emerges through complexity, irregularity, or resistance to concise form.

17.6.3 Surprise

Surprise enters epistemic orientation through a different route. It arises when an encounter departs materially from an expectation, pattern, model, classification, or anticipated trajectory. Section 17.5 treated salience and wonder as parts of the pre-history of inquiry. Surprise becomes analytically distinct here because established inquiry already contains expectations against which deviations can be recognized.

A surprising result can redirect attention because it carries information about the limits of an existing representation. An anomalous observation can reveal that a model's domain is narrower than assumed. An unexpected historical juxtaposition can expose a missing relation. A counterexample can dissolve an apparently stable generalization. A simulation can produce a regime that had not been anticipated from local intuition. Surprise can therefore function as a signal that existing epistemic organization deserves revision or extension.

The value of surprise depends on background expectations. An event that surprises a novice can be routine to an expert, while a small deviation can be highly significant within a mature measurement practice. Surprise is therefore relational to knowledge, instrumentation, disciplinary memory, and the scale at which expectations are formed. It can also be manufactured. Publication systems, media environments, and platform ranking can reward novelty claims, extreme contrasts, and rhetorically surprising framings because these attract attention. An economy of attention can consequently generate incentives to produce the appearance of surprise independently of durable epistemic significance.

This distinction matters for resource allocation. If surprise becomes a dominant selection criterion, replication, maintenance, negative results, incremental measurement, archival work, and cumulative refinement can receive less attention even when they are necessary for epistemic reliability. Conversely, an epistemic system that suppresses surprise can become insensitive to anomalies and protect established categories from revision.

Definition 17.89 (Epistemically consequential surprise). *Epistemically consequential surprise* is an expectation-disrupting encounter whose investigation can materially change a representation, question space, evidential practice, or set of plausible future inquiries.

Definition 17.89 separates durable epistemic consequence from attention value alone. The distinction is often unavailable at first encounter, which is precisely why

institutions need portfolios capable of investigating anomalies while resisting incentives that equate novelty with importance.

17.6.4 Depth

Depth is among the least easily formalized qualities used in research judgment. Researchers nevertheless distinguish questions that appear locally solvable from questions that seem to reach across levels, reorganize assumptions, expose hidden dependencies, or generate consequences well beyond their initial formulation. The vocabulary of depth often records a judgment that an inquiry contains more relational structure than its surface formulation immediately reveals.

GRE can treat depth provisionally as an orientation toward latent consequence. A deep question may connect several domains, require reconsideration of background categories, generate new methods, or remain productive across repeated investigations. A deep explanation may reveal a mechanism or relation that reorganizes many previously separate observations. A deep conceptual distinction can alter what later researchers are able to perceive or formulate. These possibilities align depth with the generative architecture developed in Chapters 14 and 15, while preserving the distinction between anticipated depth and realized generative value.

Depth should also be separated from difficulty. A problem can be technically difficult because of scale, computation, data scarcity, or cumbersome formalism while producing little conceptual reorganization when solved. A comparatively simple observation can prove deep if it changes the relation among many other questions. Likewise, obscurity can be mistaken for depth when opacity itself becomes a prestige signal. An epistemic economy that rewards difficulty, abstraction, or specialized language as proxies for depth can misallocate attention.

The recognition of depth depends strongly on accumulated knowledge. Detecting that a modest anomaly threatens a foundational assumption requires an understanding of the surrounding structure. Recognizing that a conceptual distinction can travel across domains requires comparative experience. Depth judgments therefore depend on education, disciplinary memory, cross-domain exposure, and time for reflection. They are partly capability judgments as well as judgments about objects.

A further temporal problem follows. The depth of an inquiry can become visible only retrospectively. Questions initially treated as marginal can later reorganize a field after new methods, evidence, or social conditions make their implications accessible. Institutional systems that demand short-cycle demonstrations of importance can therefore underprovide for forms of inquiry whose depth is revealed through delayed recombination.

Within GRE, depth is best treated as a provisional expectation concerning the scale and durability of relational consequence. It can orient exploration, while evaluation remains open to the possibility that apparent depth dissipates under investigation or that overlooked work acquires depth through later historical conditions.

17.6.5 Generative Promise

Beauty, elegance, surprise, and depth can contribute to a broader judgment concerning *generative promise*. This judgment concerns the anticipated capacity of an inquiry to open later possibilities: new questions, methods, relations, representations, capabilities, collaborations, applications, or reinterpretations. Generative promise belongs naturally within GRE because Chapters 14 and 15 already distinguish the generation of future possibilities from static possession of present value. The present subsection concentrates on the epistemic use of that distinction before outcomes are known.

Definition 17.90 (Generative promise in inquiry). *Generative promise in inquiry* is a provisional judgment that committing resources to an epistemic trajectory may enlarge, diversify, or reorganize future capacities for knowing, questioning, interpreting, or acting, while the particular downstream consequences remain materially uncertain.

Generative promise differs from immediate expected output. A project can promise a specific article, dataset, model, or application while leaving the surrounding question space largely unchanged. Another project can have a comparatively uncertain direct output while developing an instrument, concept, archive, method, or relation that enables many later inquiries. Section 17.5 described this temporal problem through open-use inquiry. Generative promise supplies one way in which researchers and institutions orient within that uncertainty.

The judgment can draw on several cues. Elegance may suggest that a representation can travel efficiently. Surprise may indicate that an existing framework has opened. Depth may suggest consequences across levels or domains. Beauty may stabilize attention long enough for an initially obscure relation to be developed. Additional cues can include tractability, availability of evidence, complementarity with existing capabilities, the formation of new research communities, or the creation of reusable infrastructure. None of these cues establishes future value by itself.

Generative promise is especially difficult to govern because it is anticipatory. Evaluation systems can easily reward realized outputs and standardized indicators, whereas the value under consideration concerns futures that do not yet exist. This creates a problem of institutional imagination. Reviewers often judge a trajectory partly by its capacity to produce possibilities whose content remains only partially specifiable in advance. Excessively narrow prediction requirements can therefore favor projects whose outputs are already legible within current categories.

Proposition 17.91 (Generative-promise allocation). *When epistemic investment has materially uncertain downstream consequences, an evaluation architecture can preserve future option value by considering plausible generative promise alongside present quality, feasibility, responsibility, and resource cost, while treating the promise as revisable rather than as realized value.*

Proposition 17.91 places speculative and cumulative work within the same portfolio problem. It identifies one dimension that can disappear when evaluation is restricted to near-term deliverables. A diversified epistemic portfolio can contain projects with different combinations of immediate reliability, infrastructural value, exploratory uncertainty, and generative promise.

17.6.6 Research Taste

Researchers rarely apply beauty, elegance, surprise, depth, feasibility, and generative promise as separate explicit scores. Experienced judgment often integrates multiple cues into a comparatively rapid sense that a problem, method, representation, or result deserves further attention. Hume's account of cultivated taste emphasizes practice, comparison, and delicacy of judgment, while McAllister shows how scientific communities can develop historically variable aesthetic preferences (Hume 1985; McAllister 1996). These traditions support a conception of research taste as learned discrimination rather than arbitrary preference.

Definition 17.92 (Research taste). *Research taste* is a historically formed and revisable capacity to discriminate among epistemic possibilities by integrating form-sensitive, epistemic, practical, and generative cues under conditions where explicit evaluation remains incomplete.

Research taste can operate at several moments. It can influence which anomaly receives attention, which conjecture feels worth testing, which representation captures an essential relation, which empirical discrepancy appears consequential, which simplification is illuminating, and when an inquiry has become repetitive or exhausted. It can also shape the sequencing of work by identifying which intermediate problem may unlock a larger structure.

This capacity can contain compressed experience. Years of comparison can make certain failure modes immediately perceptible. Familiarity with a literature can reveal that an apparently novel problem has weak generative potential. Cross-disciplinary experience can expose a relation that remains invisible within a single vocabulary. Such judgment often precedes a complete verbal account of its basis. The economic consequence is that expertise can improve the allocation of scarce inquiry effort even when the operative criteria are partly tacit.

Tacitness also creates governance problems. Research taste can inherit exclusions, status hierarchies, canonical blind spots, and stylistic preferences. A senior scholar's judgment may encode substantial accumulated experience while also reflecting a field's historical boundaries. Treating status as a sufficient proxy for taste can therefore reproduce established orientations. A blanket dismissal of tacit judgment would discard a significant form of acquired capability. The relevant institutional problem is to make taste contestable through comparison, plural evaluation, evidence, and exposure to alternative traditions.

Research taste also has a distributed form. Laboratories, editorial communities, research institutes, funding panels, and interdisciplinary teams can develop collective repertoires for recognizing promising work. These repertoires can exceed the competence of any one member when different forms of expertise are combined. They can also become conformist when common training and incentives narrow the range of admissible aesthetic or epistemic forms.

AI systems add another layer. They can generate polished candidate formulations, proofs, designs, visualizations, and conceptual combinations at low marginal cost. This can enlarge the material available for judgment while increasing the importance of discriminating among superficially coherent outputs. The immediate economic effect is a partial shift in scarcity: generation becomes cheaper in some tasks, while

research taste, verification, historical judgment, and sustained orientation can become more consequential bottlenecks. Chapter 18 develops the stronger capability-asymmetry problem; the present chapter retains the narrower focus on epistemic allocation.

17.6.7 Historical Formation of Taste

Research taste has a history. Disciplines teach exemplary problems, canonical proofs, influential experiments, preferred forms of evidence, acceptable styles of explanation, and tacit standards of seriousness. Kuhn's account of paradigms and exemplars makes problem selection and puzzle recognition historically organized, while Bourdieu's analysis of taste emphasizes the formation of dispositions through social trajectory, field position, and cultural competence (Kuhn 1962; Bourdieu 1984). McAllister adds a specifically scientific account in which aesthetic criteria can change as communities reinterpret the relation between prior success and preferred theoretical form (McAllister 1996).

These lineages suggest that taste is simultaneously enabling and selective. Training enables a researcher to see distinctions, patterns, and possibilities that would otherwise remain unavailable. The same training can make unfamiliar forms appear unserious or aesthetically deficient. Canon formation concentrates collective memory around work considered exemplary, which lowers learning costs and preserves cumulative achievement. It also affects which alternative traditions, negative results, peripheral problems, and unsuccessful but instructive experiments remain available for later reinterpretation.

Historical formation occurs through institutions as well as texts. Admission, mentorship, seminar culture, peer review, journal style, grant evaluation, prize systems, conferences, disciplinary associations, laboratories, and research infrastructures all contribute to what researchers repeatedly encounter and learn to value. These processes can stabilize productive standards. They can also create path dependence when past allocations determine the competencies and criteria through which future opportunities are evaluated.

The historical account complicates any simple opposition between authentic judgment and social influence. A researcher's capacity to recognize elegance or depth may genuinely improve through participation in a field, and that field can simultaneously transmit contingent exclusions. The relevant analytical task is provenance: which experiences, comparisons, institutions, and histories formed the judgment, and how well does the resulting taste perform when confronted with evidence, alternative perspectives, and changing objects?

Taste can also transform through encounters that resist inherited standards. New instruments can reveal phenomena whose irregularity strains established ideals of elegance. Interdisciplinary work can introduce alternative criteria of significance. Participation by previously excluded communities can alter which problems appear consequential. Technological change can make formerly infeasible questions tractable. Aesthetic orientation is therefore historically revisable through changes in both the epistemic object and the relational field of judgment.

This revisability matters economically because evaluation criteria allocate re-

sources. Once a style of inquiry becomes associated with excellence, funding, hiring, publication, and prestige can reinforce the capacities needed to reproduce that style. Historical taste can thereby become materially self-reinforcing. Reflexive epistemic institutions require mechanisms through which established criteria can be compared against neglected evidence, emerging problems, and alternative modes of inquiry.

17.6.8 Economic Conditions of Orientation

Aesthetic orientation depends on economic conditions because capacities for judgment require formation, exposure, time, security, and institutional support. The distribution of research taste therefore extends beyond the distribution of individual preference or talent. Education affects the repertoire of forms a person can discriminate. Libraries, archives, laboratories, museums, datasets, instruments, and computational systems affect the range of objects available for comparison. Mentorship and communities provide feedback. Material security affects whether uncertain questions can be pursued long enough for their structure to become visible. Funding and evaluation systems determine which forms of taste acquire organizational consequences.

Table 17.6 summarizes several recurring economic conditions. The entries are analytical dimensions rather than a closed taxonomy. Their purpose is to show how an apparently personal judgment can depend on resources and institutions distributed across an epistemic system.

Several implications follow. First, the ability to develop research taste is itself an unequally distributed capability. A researcher with protected time, broad access, experienced mentors, travel, interdisciplinary contact, high-quality infrastructure, and freedom to pursue uncertain questions can accumulate a richer comparison set than a researcher working under persistent scarcity. The resulting difference can later appear as an individual difference in “vision” even when part of its formation was institutional and economic.

Second, evaluation architectures shape the taste they later observe. If funding repeatedly rewards short time horizons, standardized methods, familiar output formats, and easily measurable novelty, researchers adapt to those criteria. Training and collaboration then develop around the rewarded forms. The evaluation system does more than select among pre-existing tastes; over time it participates in producing the dispositions through which future work is judged.

Third, plural epistemic portfolios can preserve corrective capacity. Different fields legitimately cultivate different aesthetic and epistemic standards, and even within a field several styles of inquiry can reveal different structures. Supporting some diversity of methods, temporal horizons, representations, and evaluative communities can reduce dependence on a single historically inherited conception of elegance or depth. Diversity here is an epistemic design consideration rather than a guarantee of superior outcomes in each project.

Fourth, aesthetic orientation can interact with power. Positions able to define what counts as elegant, deep, serious, or promising can redirect collective attention before formal evidence is complete. Such authority can be justified partly by expertise, yet

Table 17.6: Economic conditions shaping epistemic orientation

Condition	Contribution to orientation	Possible distortion under scarcity or concentration
Time and continuity	Enables comparison, incubation, revision, and recognition of delayed structure	Short cycles favor immediately legible questions and outputs
Material security	Supports persistence under uncertain return	Precarity increases the cost of exploratory or long-horizon inquiry
Education and mentorship	Builds repertoires for discriminating form, quality, and consequence	Unequal access concentrates cultivated judgment and recognized taste
Exposure and diversity	Expands the set of examples, methods, traditions, and anomalies available for comparison	Homogeneous exposure can stabilize shared blind spots and stylistic convergence
Infrastructure	Makes objects, traces, instruments, data, computation, and archives available for judgment	Infrastructural concentration narrows who can encounter and evaluate frontier possibilities
Evaluation regimes	Convert judgments into funding, publication, hiring, and institutional attention	Narrow metrics can reward legibility, conformity, novelty signals, or short-horizon outputs
Institutional memory	Preserves unsuccessful, marginal, cumulative, and historical work for later reinterpretation	Selective preservation can make alternative trajectories disappear from the future comparison set
Generative technologies	Expand candidate representations, combinations, and exploratory variation	Abundant polished outputs can increase verification and discrimination burdens

its consequences become more significant when the same positions also control funding, publication, hiring, infrastructure, or access. Section 17.7 develops this wider problem through epistemic asymmetry.

Proposition 17.93 (Economic formation of epistemic orientation). *Where time, security, education, exposure, infrastructure, and evaluative authority are unequally distributed, differences in epistemic orientation can partly reflect unequal conditions for forming and exercising research taste; assessment of epistemic opportunity should therefore include the economic conditions under which judgment capacities develop.*

Proposition 17.93 identifies an economic layer of judgment while preserving the importance of individual experience, contingency, disciplinary practice, and the resistant properties of epistemic objects. The capacity to recognize promising inquiry is partly produced within a distribution of opportunities.

Aesthetic judgment therefore occupies a bounded but consequential position in the epistemic economy. Beauty can stabilize attention; elegance can compress and transmit structure; surprise can expose the limits of expectation; depth can orient inquiry toward latent consequence; and generative promise can support investment in uncertain future possibility. Research taste integrates such cues through historically formed judgment, while institutions shape the conditions under which that judgment develops and acquires allocative force. Once these capacities and authorities are distributed unevenly, orientation becomes connected to asymmetry. Section 17.7 therefore examines epistemic asymmetry in knowledge, interpretation, verification,

computation, institutions, and AI-mediated capability.

17.7 Epistemic Asymmetry

Epistemic asymmetry gives the chapter a relational account of unequal epistemic position. Sections 17.1–17.6 treated knowledge, scarcity, abundance, attention, curiosity, and orientation as economic objects and processes. The present section asks how uneven capacities to know, interpret, verify, compute, and act through institutions become economically consequential when they are distributed across interdependent positions. Its objective is to decompose epistemic asymmetry into analytically distinct forms, examine how those forms can reinforce or offset one another, identify the mechanisms through which they convert into economic power, and specify the conditions under which they become persistent. The discussion proceeds through knowledge, interpretive, verification, computational, institutional, and AI-mediated asymmetries before turning to conversion and persistence. The method is relational and mechanism-oriented. It reuses Chapter 16's distinction between asymmetry and power while treating the epistemic capacities themselves as economic objects whose production, access, maintenance, and reproduction require resources and institutions.

The section begins from the epistemic-asymmetry profile established in Chapter 16. That profile records differences in knowledge, evidence, interpretation, verification, prediction, computation, institutional memory, and recognized credibility, together with the relations through which those differences can be compensated, shared, contested, converted into dependence, or translated into economic power. Chapter 17 adds an economic specialization: epistemic asymmetries are themselves produced and transformed through education, infrastructure, organizational position, time, material security, data access, standards, legal rights, technological systems, and cumulative learning. Their distribution therefore reflects both present capability and the historical organization of epistemic opportunity.

Definition 17.94 (Economic epistemic asymmetry). For a specified economic relation, field, and horizon, an *economic epistemic asymmetry* is a directional difference between positions in one or more epistemically relevant capacities whose formation, exercise, accessibility, or consequence is materially organized through economic resources, institutions, infrastructures, or dependencies.

Definition 17.94 is deliberately plural. A position can possess superior factual knowledge while lacking interpretive competence; possess strong interpretation while lacking means of independent verification; possess computational scale while lacking local context; or possess institutional authority while depending on external technical expertise. Epistemic position is therefore represented here as a multi-dimensional configuration whose components can diverge. Hayek's analysis of dispersed knowledge remains a useful precedent for this distributed view: economically relevant knowledge is often fragmented across actors and locations rather than concentrated in a single omniscient position (Hayek 1945). GRE extends the point by asking how heterogeneous epistemic capacities are economically formed, connected, and converted.

Table 17.7: Principal forms of epistemic asymmetry in the epistemic economy

Form	Primary difference	Characteristic economic consequence
Knowledge	Possession or practical access to relevant facts, records, experience, models, or domain knowledge	Unequal uncertainty reduction, anticipation, bargaining position, or access to feasible action
Interpretive	Capacity to contextualize, classify, translate, explain, or assign significance to epistemic material	Unequal ability to make evidence actionable, contest categories, or define the meaning of a situation
Verification	Capacity to test, reproduce, audit, authenticate, triangulate, or challenge claims	Unequal dependence on testimony, certification, models, or externally supplied judgments
Computational	Access to compute, algorithms, technical expertise, software, data pipelines, or scalable search and simulation	Unequal speed, scale, predictive reach, experimentation, or feasible search space
Institutional	Position within organizations, professions, standards, archives, credentials, review systems, or recognized authority	Unequal ability to produce authoritative records, admit evidence, certify claims, set categories, or stabilize knowledge
AI-mediated	Unequal access to, control over, or capacity to evaluate generative and predictive AI systems and their complements	Simultaneous diffusion of some expertise and concentration of generation, evaluation, infrastructure, or decision capacity

Table 17.7 summarizes the six forms developed below. The distinctions are analytical. One empirical relation can contain several forms at once, and the same technological or institutional arrangement can reduce one asymmetry while enlarging another.

Table 17.7 also clarifies why the section does not reduce epistemic asymmetry to information possession. Economically consequential differences can arise after information becomes formally available, because interpretation, verification, computation, and institutional uptake determine whether the information can be converted into practical capability. Conversely, specialized asymmetries can support coordination when they are connected through trustworthy delegation, translation, review, reciprocity, and contestability. The analytical task is to identify the relation through which a difference acquires consequence.

17.7.1 Knowledge Asymmetry

Knowledge asymmetry is the most familiar form, yet its economic structure is broader than unequal possession of information in a transaction. Positions can differ in access to records, local experience, scientific knowledge, legal interpretation, technical documentation, historical memory, forecasts, tacit know-how, or the provenance needed to understand a claim. The asymmetry can concern what is known, how recently it is known, how reliable it is, whether it can be retrieved when needed, and whether the holder can connect it to a practical decision.

The distributed character of knowledge means that asymmetry frequently runs

in several directions at once. A firm can know its production process better than a regulator, while the regulator knows the legal and comparative field better than the firm. A physician can possess specialized clinical knowledge while a patient possesses experiential knowledge about symptoms and priorities. A platform can possess aggregate behavioral data while users possess local context that the aggregate representation omits. A central organization can possess standardized indicators while a local community possesses knowledge of relationships, histories, and informal constraints. The relevant comparison therefore concerns a specified epistemic object and economic process and avoids a global ranking of who “knows more.”

Knowledge asymmetry can improve coordination through specialization. Division of epistemic labor allows positions to develop expertise without requiring each participant to reproduce the full knowledge base of the system. Professional services, technical supply chains, scientific collaboration, and complex organizations all depend on such differentiation. The economic issue arises in the architecture connecting specialized positions. Delegation can be effective where the knowledge holder is accountable, the relevant claim is reviewable, and the dependent position has practicable routes to obtain reasons, alternatives, representation, or remedy.

Economic consequence increases where the knowledge difference affects alternatives or timing. Early knowledge of a regulatory change can alter investment decisions; superior knowledge of product quality can affect bargaining; proprietary process knowledge can create switching costs; historical records can strengthen a legal or organizational claim; awareness of hidden maintenance risk can change the value of an asset. In each case the asymmetry matters because it enters a consequential pathway, not because unequal knowledge carries an intrinsic economic sign.

Knowledge asymmetry can also be endogenous to prior economic allocation. Education, protected learning time, access to archives, high-quality data, professional networks, field experience, and participation in decision processes affect what can be learned. A present difference in knowledge can therefore partly reflect earlier differences in access to epistemic resources. Section 17.8 will examine the cumulative side of this process through knowledge capital. The present subsection retains the narrower comparative object: a directional difference in economically relevant knowledge at a specified point or interval.

Proposition 17.95 (Knowledge-asymmetry scope condition). *A claim of knowledge asymmetry should identify the epistemic object, the positions being compared, the time or decision horizon, the relevant access and reliability conditions, and the economic process through which the difference could matter; a general difference in information possession is insufficient to specify its economic significance.*

Proposition 17.95 keeps the analysis compatible with distributed knowledge. It also prevents later power analysis from treating every informational difference as a one-directional advantage.

17.7.2 Interpretive Asymmetry

Interpretive asymmetry concerns the unequal capacity to make epistemic material intelligible, contextually meaningful, and actionable. Two positions can possess the same document, dataset, model output, legal text, medical record, or historical

archive while differing sharply in their ability to understand its significance. Interpretation requires vocabularies, background knowledge, comparison classes, causal expectations, disciplinary conventions, and sometimes familiarity with the lived or institutional context from which the material emerged.

This asymmetry is economically important because formal access can coexist with practical opacity. Disclosure of a contract does not equal the capacity to understand its risk allocation. Publication of a model does not equal the capacity to interpret its assumptions. Open data do not equal the competence to identify measurement artifacts. A legal right to inspect records does not by itself supply the conceptual resources needed to contest the classification embedded in them. Section 17.2 therefore distinguished access from expertise, while the present subsection isolates the interpretive relation that can remain unequal after access has been obtained.

Interpretive asymmetry can arise from specialization, language, education, cultural distance, disciplinary boundaries, organizational role, or unequal participation in the production of categories. Fricker's account of testimonial and hermeneutical injustice is relevant here because it shows how credibility and shared interpretive resources can be unequally distributed, affecting whether experiences become intelligible and receivable within collective epistemic practice (Fricker 2007). GRE uses this precedent descriptively before any justice judgment: interpretive asymmetry can exist wherever positions differ materially in their capacity to articulate, translate, contextualize, or have an interpretation recognized.

Interpretive capacity is also relational. A technical expert can understand a model while lacking contextual knowledge of the population to which it is applied. A local actor can recognize the meaning of an event while lacking the institutional vocabulary through which that meaning becomes admissible in a formal process. Productive interpretation often requires combining these partial capacities. Institutions that treat one vocabulary as exhaustive can therefore convert a complementary difference into exclusion or dependence.

Classification systems illustrate the mechanism. Categories simplify complex fields and support coordination, comparison, and administration. Their meaning is rarely exhausted by their labels. Bowker and Star show how classifications and standards become infrastructures that organize visibility and interaction (Bowker and Star 1999). Positions capable of interpreting the provenance, exclusions, and operational effects of a classification can act differently from positions that encounter only the resulting label. The asymmetry lies partly in access to the interpretive history of the category.

Interpretive asymmetry can consequently shape agenda formation. A position that can name a pattern, connect dispersed evidence, and translate it into a recognized problem can make a claim actionable earlier than a position that experiences the same pattern without an accepted vocabulary. Section 17.5 treated question formation as economically conditioned; interpretive asymmetry adds that the ability to formulate a consequential question can itself be unevenly distributed.

Definition 17.96 (Interpretive capability). For a specified epistemic object and practical field, *interpretive capability* is the situated capacity to connect available epistemic material with relevant concepts, context, provenance, comparison, and possible con-

sequence in a form that can support understanding, communication, contestation, or action.

Definition 17.96 treats interpretation as a capability that extends beyond possession of a vocabulary. It can be individual, collective, or distributed across persons and artifacts. Its economic formation depends on education, language, participation, time, institutional memory, and access to communities of practice.

17.7.3 Verification Asymmetry

Verification asymmetry concerns unequal capacity to test whether a claim, record, model, artifact, or representation deserves reliance. Section 17.3.5 identified verification as a scarcity that can become more important when candidate outputs proliferate. The present problem is distributive and relational: some positions possess the data, expertise, tools, permissions, time, or institutional standing required to check a claim, while others rely on certification, testimony, reputation, or another position's evaluation.

Verification should be understood broadly. Depending on the field, it can include replication, audit, provenance inspection, authentication, cross-source comparison, remeasurement, code review, legal discovery, model validation, adversarial testing, source criticism, maintenance inspection, or the capacity to obtain an independent second opinion. Different fields therefore generate different verification infrastructures and costs.

The asymmetry becomes economically salient when reliance is consequential and independent checking is expensive or impracticable. A consumer may be unable to inspect the safety of a complex product; an employee may be unable to audit an algorithmic performance score; an investor may rely on audited accounts; a hospital may depend on certified equipment; a public agency may rely on a vendor model whose internal behavior is difficult to examine. The practical relation can remain legitimate where verification is delegated to accountable institutions. The asymmetry itself identifies who can check what, through which means, and at what cost.

Verification capacity can be concentrated through technical complexity, secrecy, intellectual-property arrangements, data localization, proprietary infrastructure, specialized instrumentation, or high fixed costs. It can also be widened through open methods, reproducible workflows, interoperable records, independent auditing, public testing facilities, shared standards, and preserved provenance. The economic architecture therefore affects whether verification is a private capability, a public infrastructure, a professional service, or a distributed collective practice.

Machine-learning systems illustrate why verification asymmetry deserves separate treatment. Burrell distinguishes several sources of opacity, including intentional secrecy, technical-literacy barriers, and opacity arising from model characteristics and scale (Burrell 2016). Kroll and colleagues likewise show that accountability for algorithmic decision systems can require technical and institutional mechanisms beyond ordinary inspection of a human decision maker (Kroll et al. 2017). These analyses support a GRE distinction between access to an output and capacity to evaluate the process that produced it.

Verification asymmetry can recursively affect trust. Where a position repeatedly cannot inspect a consequential claim, it may rely increasingly on the reputation or institutional authority of the verifier. That reliance can be efficient when verification institutions are competent and accountable. It can become a source of vulnerability when alternatives are weak and challenge is costly. Section 17.7.7 will treat the conversion of such dependence into power.

Proposition 17.97 (Verification-dependence condition). *Where practicable checking of an economically consequential claim is unavailable to an affected position within the relevant horizon, reliance shifts toward external verifiers, credentials, institutions, or infrastructures; the resulting dependence is shaped by the availability, independence, accessibility, and contestability of those verification arrangements.*

Proposition 17.97 remains compatible with trusted division of verificatory labor across complex epistemic economies. Direct verification by each participant is only one possible arrangement. The proposition identifies the institutional conditions that make delegated verification consequential.

17.7.4 Computational Asymmetry

Computational asymmetry arises when positions differ materially in the capacity to search, process, simulate, optimize, infer, predict, retrieve, or generate epistemic outputs through computational systems. The relevant resources include hardware, cloud access, data pipelines, algorithms, software, technical labor, energy, networking, and the organizational competence required to combine them. Computational capacity therefore enters the epistemic economy as a composite capability combining compute with data, software, expertise, energy, networks, and organization.

This asymmetry can alter scale. A position with substantially greater computational capacity can evaluate more candidate configurations, analyze larger datasets, perform faster simulations, run more experiments, update models more frequently, or personalize decisions across a large population. The advantage can concern speed, breadth, granularity, or the feasible search space. In markets where timing matters, even a modest improvement in processing speed can change opportunity. In scientific or engineering settings, expanded computation can make questions feasible that were previously inaccessible.

The relation to knowledge remains mediated. More computation can process poor data, amplify a mistaken model, or produce outputs that exceed available interpretive and verificatory capacity. Computational asymmetry should therefore remain analytically separate from knowledge superiority. A smaller organization with better local data or domain understanding can outperform a larger computational system on a bounded problem. Conversely, computational scale can compensate for limited human attention by automating search and comparison. The economically relevant capability is the configuration of computation with data, models, expertise, and institutional use.

High fixed costs can produce concentration. Specialized chips, data centers, energy supply, networking, proprietary software, large-scale datasets, and scarce technical expertise can be difficult to reproduce independently. Access can nevertheless be partially diffused through cloud services, shared research infrastructure, open-

source software, public computing facilities, consortia, and standardized interfaces. Computational asymmetry is therefore shaped by ownership and control, yet it is not reducible to either. A position can own little infrastructure while purchasing large-scale access; another can own infrastructure whose effective use is limited by software, data, or expertise.

The distribution of computational capacity also affects verification. Large-scale model auditing, simulation, stress testing, replication, and search for failure cases can themselves require substantial compute. A system can therefore generate an epistemic asymmetry twice: first in the capacity to produce an output, and again in the capacity to challenge it. This second-order asymmetry becomes especially important where model scale or complexity raises the cost of independent evaluation.

Computational asymmetry is historically dynamic. Technical improvements can lower costs and widen access while frontier systems simultaneously increase their resource requirements. The direction of inequality can therefore differ across layers: routine computational capability can diffuse even as frontier training, proprietary data, specialized hardware, or integrated infrastructure remain concentrated. Section 17.7.6 develops this layered pattern for AI-mediated systems.

17.7.5 Institutional Asymmetry

Institutional asymmetry concerns unequal epistemic capacity that arises from position within organizations, professions, legal systems, standards regimes, archives, credential structures, or recognized decision processes. Institutions do more than store knowledge. They authorize some records, stabilize categories, define evidential thresholds, preserve memory, assign responsibility, and determine which interpretations can acquire official consequence. Epistemic capability therefore depends partly on where a position stands within these arrangements.

Several mechanisms are recurrent. An institution can grant privileged access to records; recognize some credentials and exclude others; authorize particular actors to certify a claim; preserve some histories more systematically than others; define the categories through which cases are processed; determine which evidence enters a hearing; or create professional roles whose judgments carry presumptive weight. Porter documents how standardized quantitative practices can acquire institutional authority by supporting impersonal and comparable judgment, while Bowker and Star show how classifications and standards become embedded in infrastructures (Porter 1995; Bowker and Star 1999). These precedents illustrate why institutional asymmetry can persist even when the underlying information is formally public.

Institutional asymmetry can support reliability. Specialized review bodies, scientific communities, courts, professional licensing systems, statistical agencies, and archival institutions can accumulate competence that dispersed participants would struggle to reproduce. The relevant economic question concerns the architecture of recognition and access around that competence. Authority can be made more accountable through reason-giving, appeal, plural expertise, transparent standards, independent review, public records, and routes for affected positions to introduce counterevidence.

Institutional position can also determine who has continuity. Organizations often

remember through files, routines, databases, personnel, and standing committees. Individuals outside the institution may encounter the same issue episodically and lack the resources to reconstruct prior decisions. This creates an asymmetry of historical memory. Repeated institutional participation can therefore accumulate interpretive and strategic advantage even without a dramatic difference in factual knowledge at any single moment.

Another asymmetry concerns agenda access. Institutions possess finite attention, and formal procedures specify which claims can enter a review process, who can submit them, what format they must take, and when they can be heard. A position able to translate a concern into an institutionally legible category can obtain a hearing that another position cannot. The asymmetry combines interpretive capacity with procedural standing.

Institutional asymmetries can be nested. A researcher may hold authority within a laboratory while depending on a journal, funder, data provider, or ethics board. A regulator can possess legal authority while depending on industry data and technical expertise. A firm can control internal records while depending on external standards and certification. Analysis should therefore map institutional relations across levels because formal authority and epistemic autonomy can diverge.

17.7.6 AI-Mediated Asymmetry

AI-mediated asymmetry arises when artificial systems alter the distribution of epistemic capability among positions. The distinctive feature is mediation: AI can simultaneously expand access to some forms of generation, translation, search, coding, analysis, or explanation while concentrating other capacities in the organizations that control models, data, compute, evaluation infrastructure, interfaces, or deployment settings. The relevant asymmetry therefore concerns a changing configuration of human and machine capabilities distributed across users, providers, institutions, and infrastructures.

Recent evidence already shows one equalizing pathway in bounded tasks. Experimental and workplace studies have found productivity improvements from generative AI, with larger gains for some less experienced or initially lower-performing workers in the studied settings (Noy and Zhang 2023; Brynjolfsson et al. 2025). These findings support a limited but important possibility: AI can diffuse access to routines, formulations, examples, and task-specific guidance that previously depended more strongly on accumulated experience. The effect remains task-, system-, and institution-dependent, and it does not imply equalization across the wider epistemic economy.

AI can also create new asymmetries in evaluation. A user may generate fluent outputs without possessing the domain knowledge required to verify them. An organization may deploy a model while lacking access to its training data, internal design, or full failure profile. A model provider may possess aggregate usage information unavailable to users. A downstream institution may rely on AI-generated classifications whose effective challenge requires technical expertise and records that affected positions cannot obtain. Generation capacity can therefore diffuse while verification, provenance, and governance capacity remain concentrated.

Frontier capability introduces another layer. The Stanford AI Index documents substantial industry concentration in the production of notable frontier models together with continuing growth in AI compute and infrastructure (Stanford Institute for Human-Centered Artificial Intelligence 2026). GRE treats this evidence as a contemporary indicator of infrastructural concentration, not as a fixed property of AI development. Open models, public research, falling inference costs, specialized systems, and diffusion of tooling can change the configuration over time. The analytical object is the evolving distribution of capabilities and complements.

AI-mediated asymmetry can also shift the value of human epistemic capacities. When routine generation becomes inexpensive, contextual judgment, verification, problem formation, research taste, responsibility, and the ability to integrate outputs into institutional practice can become relatively more important. Sections 17.5 and 17.6 developed two of these capacities. The result can be a redistribution of asymmetry: some production gaps narrow while orientation and validation gaps widen.

A further asymmetry concerns dependence on interface design. Model access is commonly mediated by APIs, platforms, safety policies, pricing, rate limits, context windows, retrieval systems, identity controls, and product interfaces. These arrangements influence what users can ask, which tools can be connected, what records are retained, and how outputs are delivered. Even where model weights or outputs are widely accessible, practical capability can depend on surrounding services and institutional permissions.

Definition 17.98 (AI-mediated epistemic asymmetry). An *AI-mediated epistemic asymmetry* is a directional difference in epistemic capability that is materially created, reduced, redirected, or amplified through unequal access to, control over, evaluation of, or complementary capacity around artificial-intelligence systems.

Definition 17.98 is intentionally relational. The same AI system can reduce one asymmetry and enlarge another. Chapter 18 will examine the stronger case of radical human–AI capability asymmetry; the present section remains focused on the economic distribution of epistemic capabilities within human and institutional relations mediated by AI.

17.7.7 Conversion into Power

Epistemic asymmetry becomes a power question when an unequal epistemic position is connected to another position's feasible action or future possibilities through an effective relational mechanism. Chapter 16 established this conversion discipline through its epistemic-asymmetry–power non-equivalence and its broader asymmetry–power conversion rule. The present subsection specializes those rules to the economic architecture developed above.

Several conversion mechanisms recur. Superior knowledge can condition bargaining where the less-informed position cannot estimate quality or risk. Interpretive authority can determine which account of a situation becomes institutionally operative. Verification capacity can make one position the gatekeeper of reliability. Computational advantage can shape prices, rankings, forecasts, surveillance, or allocation at a scale difficult for others to reproduce. Institutional position can determine which evidence is admissible or whose expertise is recognized. AI-mediated capability can con-

dition access to high-quality generation, prediction, translation, or decision support. Each mechanism requires a concrete pathway linking epistemic position to practical consequence.

Dependence is a common intermediate relation. A patient may depend on medical expertise, a small firm on a cloud provider, a regulator on industry data, a worker on an opaque evaluation system, or a community on an institution capable of translating its claims into recognized categories. Dependence can support valuable specialization and coordination. Power becomes analytically relevant where the epistemically advantaged position has a practically effective capacity to condition access, standing, burden, timing, exit, or future options within that dependence.

Conversion can occur without deliberate manipulation. A standardized score can become powerful because multiple institutions coordinate around it. A classification can determine eligibility because a legal system recognizes it. A technical interface can shape action because alternatives are costly. A dominant model can become an infrastructural reference point because complementary systems accumulate around it. Intent can matter for normative or legal evaluation, yet the descriptive power relation can arise from structural dependence even where no actor explicitly aims to exercise control.

Epistemic asymmetries can also counterbalance one another. Independent expert review can constrain organizational authority. Local knowledge can correct centralized models. Open data can reduce informational advantage. Public-interest computing can widen computational access. Adversarial testing can reduce verification dependence. Professional pluralism can weaken monopoly over interpretation. These arrangements change the conversion pathway even when some underlying asymmetry remains.

Proposition 17.99 (Epistemic-asymmetry conversion condition). *Within the epistemic economy, an epistemic asymmetry supports a claim of economic power when an identifiable mechanism converts the relevant epistemic difference into a practically effective capacity to condition another position's access, action, standing, burden, contestability, exit, or feasible trajectory within a specified field and horizon.*

Proposition 17.99 restates Chapter 16's inference rule at the level of the epistemic economy. Its purpose is to preserve consistency with the power architecture established in Chapter 16. The substantive extension lies in the decomposition of the asymmetry itself: power analysis can now ask whether the operative mechanism depends principally on knowledge, interpretation, verification, computation, institutional position, AI mediation, or a combination of these capacities.

Conversion is frequently compositional. A knowledge difference can become powerful because institutional authority recognizes one interpretation, verification remains costly, and computational infrastructure amplifies the resulting classification across many decisions. Treating the outcome as "information power" would conceal the chain. Mechanism-based analysis should therefore preserve the intermediate epistemic capacities that make the final conditioning relation possible.

17.7.8 Persistent Asymmetry

Epistemic asymmetry becomes persistent when the conditions that generate or reproduce the difference extend across repeated interactions, organizational cycles, or generations. Persistence differs from momentary inequality. A temporary expert advantage can disappear after training, disclosure, or diffusion. A durable asymmetry requires some mechanism through which capability, access, authority, or dependence is renewed, accumulated, inherited, or made costly to escape.

Several persistence mechanisms follow from the preceding analysis. Cumulative learning allows an advantaged position to improve more quickly because present capability makes later learning cheaper. Exclusive data can improve models, and improved models can attract further use that generates more data. Institutional authority can create records and categories that strengthen later authority. Computational scale can support services whose revenues finance additional infrastructure. Verification dependence can concentrate trust in a small number of certifiers. Educational and professional pipelines can reproduce unequal access to recognized expertise. Each mechanism links an earlier epistemic position to the conditions of later capability.

Persistence can also emerge through switching costs. A user may understand one software ecosystem, an organization may build workflows around one model or data standard, a profession may organize training around one classification, or a public institution may depend on a long-standing vendor. Changing the epistemic infrastructure then requires more than purchasing an alternative. Records, routines, skills, integrations, legal permissions, and institutional expectations can all require conversion. These complementarities can stabilize asymmetry even when competing knowledge or technology exists.

Historical memory is another mechanism. Institutions that preserve records, provenance, prior decisions, and accumulated interpretive experience can act with a temporal depth unavailable to positions whose knowledge is repeatedly reconstructed from the present. Preservation can therefore generate legitimate capability and durable advantage at the same time. Section 17.13 will return to preservation as an epistemic good and a governance problem.

Persistent asymmetry can become self-reinforcing through power, yet persistence of asymmetry and reproduction of power remain distinct. Chapter 16 showed that an asymmetry may persist after the mechanism that once converted it into power has weakened, while power can migrate across carriers. The same distinction applies here. A firm can retain superior data without retaining market gatekeeping power; an institution can retain recognized expertise while independent review weakens its unilateral authority; a computational gap can persist while public access arrangements reduce dependence on the advantaged provider.

Countervailing mechanisms can therefore target persistence at different points. Education and translation can widen interpretive capability. Open standards and interoperability can lower switching costs. Independent audit can reduce verification dependence. Public archives can distribute historical memory. Shared computing facilities can widen computational capacity. Contestable procedures can reduce the authority attached to institutional position. Data portability and model documentation

can improve exit and review. Their effects should be evaluated against the specific asymmetry, affected capacities, and institutional objectives involved.

Definition 17.100 (Persistent epistemic asymmetry). *A persistent epistemic asymmetry is an epistemic capability difference whose supporting conditions are materially renewed, accumulated, inherited, institutionally stabilized, or made costly to replace across the relevant historical horizon.*

Proposition 17.101 (Persistence-mechanism condition). *A claim that an epistemic asymmetry is persistent should identify the mechanism that carries the difference across time, such as cumulative learning, exclusive access, institutional authority, infrastructural complementarity, switching cost, path-dependent standards, preserved memory, or recursive data and capability accumulation.*

Definition 17.100 and Proposition 17.101 prepare the next section. Once epistemic advantages can accumulate, reproduce, and alter the cost of generating further capability, they begin to resemble a capital-like structure. Section 17.8 therefore turns from comparative asymmetry to *knowledge capital*: the accumulation, control, access, infrastructural embedding, rents, and intergenerational consequences of epistemic capacity.

Epistemic asymmetry thus describes a multidimensional distribution of epistemic capability with dimensions extending beyond a single informational gap. Knowledge, interpretation, verification, computation, institutional position, and AI mediation can differ across positions and combine in historically specific ways. Some differences support specialization and productive coordination; others create dependence or constrain contestability. Their economic significance depends on conversion mechanisms, and their historical significance depends on mechanisms of persistence. This decomposition allows GRE to analyze unequal epistemic position before assigning stronger claims about power, exploitation, justice, or capital.

17.8 Knowledge Capital

Knowledge capital gives Chapter 17 a historical account of accumulated epistemic capability. Section 17.7 analyzed epistemic asymmetry as a comparative relation among positions at a specified time or horizon. The present section asks when epistemic objects, capacities, relations, and infrastructures acquire a capital-like character by persisting across episodes, remaining mobilizable, and altering the cost, scope, reliability, or generative potential of later activity. Its objective is to connect accumulation with ownership, control, access, infrastructure, expansion, rent, and intergenerational advantage while preserving these as distinct dimensions. The discussion proceeds through those eight objects in sequence. The method is relational and historical: knowledge capital is treated as a configuration distributed across persons, organizations, networks, repositories, institutions, and infrastructures, with homogeneous stock representations reserved for cases in which the relevant carrier structure supports them.

The term *capital* requires scope discipline. Economic traditions use capital in several different senses, and the present chapter uses a bounded working concept that can coexist with those traditions. Human-capital analysis, for example, represents

education and training as investments that can affect later productivity and earnings (Becker 1964). Evolutionary economics has emphasized organizational routines, search, and historically accumulated capabilities (Nelson and Winter 1982). Studies of innovation have also shown that learning can be distributed across interorganizational networks and extend beyond single-firm boundaries (Powell et al. 1996). GRE draws on this cumulative intuition while retaining a broader epistemic object: economically consequential knowledge can be embodied, codified, relational, organizational, institutional, or infrastructural, and several carriers can be required for the capability to remain effective.

Definition 17.102 (Knowledge capital). For a specified field and historical horizon, *knowledge capital* is a persistent and mobilizable configuration of epistemic objects, capacities, relations, and enabling infrastructures whose accumulated organization materially affects the range, cost, reliability, productivity, or generative potential of later economic or epistemic activity.

Definition 17.102 makes persistence, mobilizability, and future consequence central. A book stored where nobody can retrieve or interpret it may preserve an epistemic trace without functioning as effective knowledge capital in the relevant field. A skill whose exercise depends on unavailable complementary equipment can remain embodied knowledge while yielding little operative capacity. A database can be valuable to one organization and nearly useless to another lacking the models, legal permissions, contextual understanding, or technical infrastructure required for use. Capital status is therefore relational to a field of complements and a horizon of possible mobilization.

Proposition 17.103 (Knowledge-capital status condition). *An accumulated epistemic object or capability warrants treatment as knowledge capital within the present framework when its persistence is carried across time, it remains practically mobilizable under identifiable conditions, and its use or availability changes later productive, epistemic, allocative, or generative possibilities in the specified field.*

Proposition 17.103 prevents accumulation from becoming synonymous with capital. Accumulated material can decay, become obsolete, lose interpretability, or remain inaccessible. Conversely, capital-like epistemic capability can exist without exclusive ownership. Public libraries, open scientific corpora, shared standards, educational systems, and professional communities can create durable epistemic capacities whose benefits are distributed across many users. The relevant questions concern how the configuration is accumulated, carried, governed, accessed, and reproduced.

Knowledge-capital status is also descriptively separate from epistemic quality, social value, and justice. A durable epistemic capability can support public health, scientific discovery, coercive surveillance, exclusionary classification, or several consequences at once. The capital concept records persistence and mobilizable future capability; later sections evaluate exploitation, justice, preservation, participation, and commons governance through their own criteria.

Table 17.8 summarizes principal carriers of knowledge capital as a selective analytical map. Empirical configurations commonly span several rows, and their economic effects depend on the relations among them.

Table 17.8 also shows why knowledge capital is frequently distributed beyond the

Table 17.8: Principal carriers and dimensions of knowledge capital

Carrier	Accumulated epistemic capacity	Conditions of effective mobilization
Persons	Skill, judgment, experience, tacit know-how, language, memory, and learned methods	Time, health, tools, recognition, complementary expertise, and opportunities for exercise
Organizations	Routines, records, procedures, teams, institutional memory, and coordinated expertise	Continuity, documentation, staffing, communication, governance, and retention of relevant complements
Networks	Trusted contacts, collaborative pathways, distributed specialization, and channels of learning	Reciprocity, connectivity, translation, participation, and durable relational access
Repositories	Archives, datasets, publications, models, code, standards, and documented provenance	Preservation, indexing, interpretability, legal access, technical compatibility, and verification capacity
Institutions	Credentials, classifications, research systems, legal rights, professional standards, and recognized authority	Legitimacy, contestability, maintenance, participation, and continued institutional recognition
Infrastructure	Libraries, laboratories, instruments, compute, communication systems, platforms, and preservation systems	Investment, maintenance, interoperability, energy and material support, skilled operation, and governed access

holder of a legal title. A scientist's capability can depend on a publicly funded laboratory, a shared disciplinary language, open literature, institutional credentials, collaborators, and accumulated instruments. A firm's proprietary model can depend on public education, external software, standards, data supplied by users, cloud infrastructure, and prior research. Capital analysis therefore requires tracing the relational configuration that makes accumulated epistemic capacity usable.

17.8.1 Knowledge Accumulation

Knowledge accumulation is the historical process through which epistemic capacity is retained, combined, revised, and made available for later use. The process can occur within persons through learning and experience, within organizations through routines and records, within networks through repeated collaboration, within repositories through preservation and documentation, and within institutions through standards, professional practices, and cumulative research. Accumulation therefore concerns more than an increase in the quantity of information. Its economic significance depends on whether earlier epistemic achievements remain connected to later capability.

Embodied accumulation provides the most familiar case. Education, training, practice, and professional experience can create capabilities whose later exercise affects productivity, judgment, income, or participation. Human-capital theory gives one established vocabulary for this investment in acquired knowledge and skill (Becker 1964). GRE retains that insight while widening the carrier architecture. Embodied capability frequently arises through collective conditions alongside individual invest-

ment: schools, teachers, languages, laboratories, professional communities, archives, standards, and institutional recognition contribute to what the individual can learn and later mobilize.

Organizational accumulation has a different form. Repeated activity can generate routines, shared repertoires, documentation, diagnostic patterns, and division of epistemic labor. Evolutionary accounts of firms emphasize routines and search as historically developed components of organizational capability (Nelson and Winter 1982). Such capacity can survive turnover when it is adequately embedded in records, procedures, teams, and infrastructures, although excessive dependence on particular individuals can make the apparent organizational stock fragile. Organizational knowledge capital therefore has a retention problem: the organization must preserve enough of the relevant relations and context for earlier learning to remain actionable.

Relational accumulation matters where knowing is distributed. Collaboration can create channels through which organizations learn from one another, and empirical work on biotechnology has shown innovation taking place through networks of interorganizational learning (Powell et al. 1996). A network can therefore carry epistemic capacity that is absent from any isolated node. Access to a trusted expert, familiarity with a collaborative protocol, or membership in a community capable of rapid verification can reduce the cost of solving later problems. The accumulated object is partly relational because its value depends on continued connectivity and reciprocal recognition.

Accumulation also contains loss. Skills can decay, archives can become unreadable, data can lose provenance, software can become incompatible, scientific claims can be superseded, organizational memory can disappear with personnel, and classifications can lose adequacy as the object changes. Preservation accompanied by weak reinterpreted capacity can leave a large symbolic archive with little practical use. Section 17.13 will examine preservation and re-epistemization directly. For knowledge-capital analysis, the relevant point is that accumulation is a net historical process involving acquisition, integration, maintenance, revision, forgetting, and obsolescence.

A useful empirical analysis should therefore ask what is accumulating, where it is carried, what preserves its interpretability, what complementary capacities are required, and what forms of depreciation or loss matter over the selected horizon. A simple count of documents, patents, credentials, publications, or data points can provide one indicator in a specific study, yet the capital claim requires evidence that the measured accumulation remains connected to later capability.

17.8.2 Knowledge Ownership

Ownership concerns legally or institutionally recognized claims over specified epistemic objects, carriers, embodiments, or uses. It can shape knowledge capital because rights over exclusion, licensing, copying, modification, transfer, or commercialization affect who can mobilize an accumulated capability and on what terms. Ownership remains one dimension of the architecture. Section 17.1 already established that the economic life of knowledge extends beyond property language, especially

where knowledge is socially produced, non-rival in some uses, historically inherited, or dependent on shared infrastructures.

The object of ownership should be specified carefully. A legal right can attach to a physical manuscript, a database, a copyrighted expression, a patentable invention, a software repository, a trade secret, equipment, or shares in an organization. The associated knowledge may also circulate through learning, observation, independent discovery, public disclosure, interoperability, or professional practice. Arrow's classic analysis of invention emphasized the unusual economics of information production, uncertainty, disclosure, and appropriation (Arrow 1962). These properties help explain why institutions often govern knowledge through layered arrangements whose structure differs from the straightforward transfer of an exhaustible object.

Ownership can support accumulation. Time-limited exclusion, licensing, confidentiality, or control over research assets can create revenue streams that finance research, curation, preservation, or development. Ownership can also alter diffusion, follow-on use, interoperability, and entry. The economic analysis therefore concerns the particular rights, their scope, duration, enforcement, and relation to complementary infrastructure. A categorical statement that ownership either promotes or inhibits knowledge generation would obscure this institutional variation.

Knowledge-commons research provides a complementary perspective by examining knowledge as a shared resource whose governance involves access, enclosure, preservation, intellectual property, contribution, and institutional design (Hess and Ostrom 2007). This perspective is useful for knowledge-capital analysis because a valuable epistemic configuration can be collectively governed. Shared ownership, public stewardship, open licensing, membership arrangements, fiduciary control, or commons institutions can preserve accumulation while distributing rights across multiple positions.

Definition 17.104 (Knowledge-ownership profile). A *knowledge-ownership profile* specifies the legally or institutionally recognized claims over a defined epistemic object or carrier, including the relevant rights of possession, exclusion, use, copying, modification, licensing, transfer, or commercialization and the positions to which those rights attach.

Definition 17.104 keeps ownership analytically separate from capability. An owner can lack the expertise required to use the asset. A licensee can possess economically powerful access without owning the underlying right. A public institution can hold an archive on behalf of a broader community. A worker can carry tacit knowledge generated through employment while contractual or institutional rules govern aspects of its disclosure. The ownership profile is therefore one layer within a wider relational configuration.

17.8.3 Knowledge Control

Control concerns the practical capacity to condition how an epistemic object, capability, or infrastructure is produced, accessed, modified, disclosed, validated, connected, or withdrawn. Control can arise through ownership, yet it can also arise through technical architecture, administrative authority, contracts, credentials, secrecy, physical custody, standards, platform rules, or control of indispensable complements. The

distinction matters because economic consequence often follows operational control more directly than formal title.

A cloud provider may control the infrastructure through which a customer uses models or data that the customer legally owns. A journal editor or standards body can influence recognized publication or classification without owning the underlying knowledge. A laboratory administrator can control scheduling and instrument access. A database steward can determine authentication, retention, and export permissions. A software maintainer can influence compatibility through updates. These arrangements distribute control across different interfaces, and one actor can control an interface while depending on other actors for the epistemic content itself.

Control is also divisible. One position can determine access while another determines modification. A profession can control certification while a public authority controls licensing. A platform can control ranking while users retain rights over some contributed content. Researchers can control interpretation while funders control continuation of the project. Treating these relations as a single binary variable would conceal the mechanisms through which knowledge capital becomes usable or dependent.

Definition 17.105 (Epistemic control profile). An *epistemic control profile* identifies the positions with practically effective capacities to condition the generation, preservation, access, modification, validation, disclosure, interoperability, or withdrawal of a specified epistemic object, capability, or infrastructure.

Definition 17.105 allows a direct comparison with Definition 17.104. Ownership supplies recognized rights; control describes effective conditioning capacities. The two can coincide, diverge, or be distributed among several positions. Their divergence becomes especially important in complex digital and institutional systems where a nominal owner depends on a platform, standard, credential, or technical operator to make the owned object economically effective.

Control can also contribute to persistence. An organization able to preserve exclusive data, govern an interface, set a standard, or retain institutional memory can carry an epistemic advantage across repeated interactions. Section 17.7 described such persistence as a property of asymmetry. Knowledge-capital analysis adds the accumulation side: control can protect or organize the carriers through which earlier epistemic investments continue to generate later capability.

17.8.4 Knowledge Access

Access concerns the practicable ability to retrieve, interpret, use, combine, verify, or participate in an accumulated epistemic configuration under the relevant temporal and institutional conditions. Access is economically important because knowledge capital can generate capability for positions that neither own nor control its principal carriers. Education systems, libraries, open-source software, shared research facilities, public data, licensed databases, professional networks, and platform services all illustrate forms in which access mediates the benefits of accumulated knowledge.

Formal permission is one component. Effective access can also depend on price, language, credentials, location, time, technical compatibility, compute, disability ac-

commodation, documentation, legal permission, institutional membership, and the ability to understand what has been retrieved. Section 17.2 analyzed these conditions as mechanisms of scarcity. Within knowledge-capital analysis, the emphasis changes: access determines which positions can draw on accumulated epistemic capacity and whether that capacity becomes a broad productive base or a narrowly usable asset.

Access can be layered. A public article can be readable while its underlying data remain restricted. A dataset can be downloadable while the compute required for analysis remains scarce. A model can be accessible through an interface while its weights, training data, or evaluation methods remain unavailable. A university can provide library access to members while outsiders rely on narrower public channels. A patent can disclose an invention while complementary manufacturing capability remains concentrated. These layers affect which component of the accumulated configuration becomes mobilizable.

Access can also be temporary or revocable. Subscription termination, account suspension, vendor exit, licensing change, platform closure, model withdrawal, or loss of professional affiliation can remove capabilities that appeared durable to the user. Analysis should therefore distinguish episodic access from secure access and identify the dependence relations attached to each. Durable knowledge capital for one position can rest on fragile access to another position's infrastructure.

Proposition 17.106 (Access–capital mobilization condition). *Where a position mobilizes a knowledge-capital configuration through access to carriers owned or controlled by other positions, its effective benefit depends on the stability, terms, complementarity, and contestability of that access relation.*

Proposition 17.106 makes access part of capital analysis without equating access with ownership. It also identifies a source of hidden fragility. A firm, researcher, household, or public agency can appear epistemically well endowed because it currently accesses high-quality infrastructure, while a change in contractual, technical, political, or institutional conditions can rapidly reduce that capability.

17.8.5 Knowledge Infrastructure

Knowledge infrastructure supplies durable material, technical, organizational, and institutional conditions through which accumulated epistemic capacity can be generated, stored, connected, verified, and mobilized. Libraries, archives, laboratories, instruments, communication networks, schools, universities, standards systems, data repositories, compute facilities, software ecosystems, preservation systems, and professional institutions can each perform infrastructural functions. Section 17.11 will analyze epistemic infrastructure in its own right. The present subsection isolates its role within knowledge capital.

Infrastructure can carry knowledge directly. An archive preserves records; a database preserves structured observations; a software library preserves executable methods; an instrument embodies accumulated engineering and calibration; a standard embeds conventions that allow multiple systems to interoperate. Infrastructure can also act as a multiplier. A trained researcher with access to advanced instrumentation can exercise capabilities unavailable through skill alone. A public dataset connected to documentation, compute, and verification protocols can support more

extensive inquiry than the same raw records held in an inaccessible format.

Historical studies of technological competition show how firms, scientific knowledge, research institutions, educational systems, and patent arrangements can coevolve over long periods (Murmann 2003). This coevolutionary perspective is useful because knowledge capital often resides in a system of complements. Publication output alone provides an incomplete indicator of a country's scientific capability, while patent counts alone provide an incomplete indicator of a firm's technological capability. Educational pipelines, laboratories, suppliers, standards, professional communities, finance, and legal institutions can jointly shape whether accumulated knowledge becomes economically productive.

Infrastructure can be shared, privately controlled, publicly funded, cooperatively governed, or institutionally mixed. Its capital contribution is compatible with public, private, cooperative, commons-based, and mixed ownership arrangements. A public library can raise the epistemic capability of households and firms. Open technical standards can lower coordination costs across organizations. Publicly supported universities can generate skills, research, and networks subsequently used in many sectors. Proprietary compute can create highly concentrated capability. The distribution of knowledge capital depends partly on how infrastructures connect these forms of accumulation and access.

Infrastructure also has maintenance and renewal costs. Servers require energy and replacement; archives require preservation; standards require revision; institutions require staffing; educational systems require teachers and facilities; instruments require calibration; software requires security and compatibility work. Knowledge capital can therefore depreciate through infrastructural neglect even when the symbolic content appears preserved. Maintenance is analytically part of the capital process because it keeps accumulated epistemic capacity mobilizable across time.

17.8.6 Knowledge Capital Expansion

Knowledge capital expansion concerns the recursive process through which existing epistemic capacity contributes to the generation, acquisition, verification, integration, or mobilization of further epistemic capacity. The process is central to GRE because knowledge can function as both an accumulated result of earlier generation and a condition affecting later generation. The resulting recursion can produce cumulative advantage, broad diffusion, organizational learning, or infrastructural deepening depending on how access, retention, and reinvestment are organized.

Existing capability can lower the cost of later learning. Prior mathematical training changes which advanced concepts can be learned; a research laboratory with established methods can test new hypotheses more rapidly; an organization with well-documented data can evaluate new models more effectively; a network of trusted collaborators can locate expertise quickly; a maintained codebase can support further experimentation; a scientific community with shared standards can compare results at lower coordination cost. Earlier accumulation therefore changes the feasible epistemic search space.

Expansion can also occur through combination. Two bodies of knowledge can become more useful when a translation, interface, model, or institutional relation al-

lows them to interact. New capability can arise through interdisciplinary collaboration, integration of datasets, connection of a theoretical framework to an instrument, or combination of domain expertise with computational tools. The resulting capital is partly relational because its generative potential depends on the interface that makes the components mutually usable.

Definition 17.107 (Knowledge-capital expansion). *Knowledge-capital expansion* is a historical process in which an existing knowledge-capital configuration contributes to the generation or acquisition of additional mobilizable epistemic capacity, and a consequential share of the resulting capacity is retained within, connected to, or made accessible through the later configuration.

Definition 17.107 requires retention. An episode can generate valuable knowledge that immediately dissipates through staff turnover, lost records, incompatible systems, institutional collapse, or inaccessible outputs. Such an episode can produce knowledge while durable capital expands only where a carrying mechanism preserves practical connection to later capability. Expansion therefore combines generation with a carrying mechanism.

Proposition 17.108 (Recursive knowledge-capital condition). *Knowledge-capital expansion becomes recursively reinforcing where existing epistemic capacity materially improves the production, selection, verification, integration, or preservation of later epistemic capacity and where the later capacity remains sufficiently connected to the configuration to influence subsequent rounds of generation.*

Proposition 17.108 identifies a possible cumulative mechanism while allowing the magnitude and sign of later returns to vary across fields and historical conditions. Expansion can encounter congestion, organizational complexity, obsolete paradigms, coordination cost, talent bottlenecks, infrastructural limits, or declining relevance. Existing capital can also bias search toward familiar questions and methods, making some alternatives less visible. Historical success can therefore create both capability and path dependence. The relevant empirical question is how the inherited configuration changes later possibility, including which possibilities it makes easier to pursue and which it leaves difficult to recognize.

The distribution of expansion matters as well. Open publication, education, interoperable standards, public infrastructure, and collaborative networks can allow one episode of accumulation to expand the capabilities of many positions. Exclusive control, restrictive interfaces, high switching costs, or concentrated infrastructure can channel expansion toward a narrower set of positions. The same research discovery can therefore contribute to a broad epistemic base in one institutional arrangement and to concentrated capital in another.

17.8.7 Knowledge Rents

Knowledge rents connect capital accumulation to economic return. Section 17.2.8 defined a knowledge-scarcity rent as the portion of return attributable, under a specified counterfactual, to control over a scarce epistemic object, capacity, recognition position, access pathway, or enabling infrastructure beyond the contemporaneous costs required to provide the relevant epistemic function. The knowledge-capital perspective adds a historical question: how can accumulated epistemic advantage create

returns that finance, protect, or expand the conditions of further accumulation?

A capital configuration can yield returns through several channels. Proprietary knowledge can support differentiated products. Specialized expertise can command high compensation. A certification position can generate fees. A platform can monetize access to accumulated data or an audience. A research infrastructure can license use. A standard can support complementary services. An organization with superior institutional memory can make better decisions and reduce costly error. These returns arise through different mechanisms, and only some warrant classification as rent under the definition established in Section 17.2.8.

The distinction between return and rent is especially important here. Compensation for research cost, skilled labor, risk, maintenance, preservation, security, and continuing development can support the reproduction of valuable knowledge capital. A rent claim requires a counterfactual showing that part of the return arises from a scarcity or control position beyond those relevant costs. Arrow's analysis of knowledge production helps explain why appropriation institutions can serve incentive functions while also shaping diffusion and market structure (Arrow 1962). GRE therefore treats rent formation as an institutional relation whose normative evaluation depends on its function, incidence, alternatives, and generative consequences.

Rents can become historically consequential when they are reinvested in the carriers of epistemic advantage. Revenue can finance additional research, acquire exclusive datasets, attract specialized personnel, build compute, strengthen legal protection, purchase complementary firms, expand certification networks, or subsidize services that attract further users. This pathway can connect scarcity, return, accumulation, and renewed scarcity. The feedback can be productive where it sustains costly research and infrastructure, and it can also deepen dependence where entry, interoperability, or contestability weakens.

Proposition 17.109 (Rent–capital feedback condition). *A knowledge rent contributes to cumulative knowledge-capital advantage when a consequential share of the return is converted into epistemic objects, capabilities, control positions, access relations, or infrastructures that materially strengthen the conditions for later accumulation or rent generation.*

Proposition 17.109 separates the existence of rent from its historical use. A rent can be consumed without enlarging epistemic capacity. A firm can expand knowledge capital through retained earnings that are not rents. Public revenue can finance shared research infrastructure without relying on proprietary scarcity. The proposition identifies only one recursive mechanism through which knowledge capital and rent can reinforce one another.

This mechanism also prepares Section 17.9. Capital accumulation and rent formation are analytically prior to and distinct from generative exploitation. Exploitation analysis requires tracing who contributes generativity, how the contribution is incorporated, which position captures the resulting value or capability, and what forms of compensation, recognition, reciprocity, or exit are available. The present section therefore stops at the capital architecture and leaves the stronger relational claim to the next section.

17.8.8 Intergenerational Knowledge Advantage

Intergenerational knowledge advantage concerns the transmission of epistemic capacity across cohorts, organizational generations, professional lineages, communities, and historical periods. Knowledge capital is especially important here because accumulated capability can outlive the persons who initially generated it. Languages, archives, schools, institutions, scientific theories, technical standards, libraries, professional practices, infrastructure, and cultural repertoires can make earlier learning available to later participants and allow them to begin from a historically accumulated epistemic platform.

Transmission can occur within households through education, books, language, expectations, networks, material security, and familiarity with institutions. It can occur within organizations through documentation, apprenticeship, routines, archives, succession, and maintained infrastructure. Professions transmit knowledge through training, journals, standards, licensing, conferences, and supervised practice. Societies transmit knowledge through schools, universities, public institutions, libraries, cultural memory, technical systems, and preserved historical traces. Intergenerational advantage therefore spans several scales beyond inheritance within families.

The transmitted object is also heterogeneous. A later position can inherit substantive knowledge, methods for generating knowledge, access to expert networks, recognized credentials, trusted institutional status, material infrastructure, or the economic resources required to sustain learning. Some inheritances widen the general epistemic base. Public education, open archives, shared standards, and durable scientific institutions can allow large populations to begin from a historically elevated platform. Other inheritances remain more concentrated because access depends on wealth, location, membership, language, proprietary systems, or historically accumulated institutional position.

Intergenerational difference and injustice remain distinct analytical objects. Long-lived knowledge institutions can be socially valuable precisely because they preserve hard-won capability. Families and communities can reasonably transmit skills, language, traditions, and educational support. Normative evaluation depends on the mechanisms of transmission, the opportunities available to other positions, the presence of exclusion or domination, the public contribution to the accumulated resource, and the consequences for later generative participation. Section 17.12 will address epistemic justice directly.

Definition 17.110 (Intergenerational knowledge advantage). An *intergenerational knowledge advantage* is a historically transmitted difference in mobilizable epistemic capacity whose carrier connects earlier accumulation to the capabilities, access, standing, infrastructure, or feasible inquiry trajectories of later positions.

Proposition 17.111 (Intergenerational transmission condition). A *claim of intergenerational knowledge advantage* should identify the transmitting carrier, the earlier accumulated epistemic resource, the later positions affected, the mechanism through which the resource remains mobilizable, and the field and horizon over which the resulting capability difference is consequential.

Definition 17.110 and Proposition 17.111 preserve the historical character of the concept. The advantage is carried through relations and institutions, so its appear-

ance in a later cohort reflects identifiable historical carriers. This makes intergenerational analysis continuous with Chapter 15's emphasis on historical trajectories and with Section 17.7's analysis of persistent epistemic asymmetry.

Knowledge capital can therefore coexist with shared ownership, with separation between ownership and effective control, with access-based use by nonowners, and with both shared and concentrated infrastructures. Its capital-like character arises from persistent mobilizable capacity and its influence on later possibility. Expansion can be recursive when accumulated capability contributes to further capability formation, while rents can become one mechanism financing renewed accumulation. Intergenerational transmission extends these processes beyond a single cohort or organizational cycle. This architecture supplies the descriptive basis for the next question. Section 17.9 examines generative exploitation in epistemic systems, where the production and expansion of knowledge capital may depend on contributions whose value, recognition, compensation, or control are distributed asymmetrically.

17.9 Generative Exploitation in Epistemic Systems

Section 17.8 developed knowledge capital as accumulated epistemic capacity whose persistence and mobilizability can alter later productive and generative possibilities. Accumulation, however, does not by itself identify the relations through which that capacity was generated, appropriated, governed, or replenished. The present section examines a stronger class of processes in which knowledge, attention, creative labor, data, interpretive work, or other epistemic contributions are asymmetrically appropriated in ways that alter the source side's control, return, options, maintenance capacity, or future generativity. Its objective is to specify when epistemic extraction becomes *generative exploitation*, while preserving distinctions among contribution, diffusion, uncompensated participation, rent, extraction, depletion, dependency, power, and injustice. The discussion proceeds through knowledge, attention, creative labor, uncompensated generativity, platform mediation, AI mediation, generative depletion, and dependency. The method is process-oriented and relational: each exploitation claim should identify a source position, a contribution or generative condition, an appropriation interface, the beneficiary or controlling position, the relevant asymmetry, the return structure, and the historical consequence for later generation.

Chapter 14 defined extraction as asymmetrical realization, appropriation, or control of value generated with material contribution from another position or shared generative configuration, accompanied by materially relevant source-side loss of control, return, option, maintenance capacity, or future generative capacity (Definition 14.21). That definition supplies the baseline here. Epistemic systems require an additional distinction because many of their inputs can be copied, recombined, or reused without physically removing the source object. Knowledge can diffuse while control over downstream conversion concentrates; attention can be repeatedly solicited while the person remains present; creative work can be reproduced while attribution, bargaining position, or future opportunity changes. The diagnostic object is therefore the *relation between contribution, appropriation, return, and future generative conditions*, rather than physical subtraction alone.

Generative justice provides a useful precedent for this focus on the relation between value generation and the conditions under which generators participate in benefits, governance, and continuing circulation (Eglash 2016; Eglash et al. 2024). GRE uses that precedent within the typed value-process architecture developed in Chapters 14–16. The result is a narrower diagnostic concept. A process can be extractive without being generatively exploitative when appropriation occurs but the source’s later generative conditions are sustained or strengthened. A source can experience generative depletion without an identifiable appropriator. Uncompensated contribution can support a voluntary commons. Dependency can be mutually productive and governed. These possibilities make mechanism-level reconstruction essential.

Definition 17.112 (Generative exploitation in an epistemic system). For a specified epistemic contribution, relation, and historical horizon, *generative exploitation* is an asymmetrical appropriation or control process in which one position materially realizes or expands epistemic, economic, institutional, or other generative capacity through contributions or generative conditions supplied by another position or shared configuration, while the source side experiences materially relevant weakening of control, return, alternatives, maintenance capacity, or future generative possibility connected to that appropriation process.

Definition 17.112 makes generative exploitation a stronger diagnosis than unequal benefit. The claim requires a traceable appropriation mechanism and a source-side generative consequence. A research organization can benefit greatly from a public dataset without exploiting its producers when access, provenance, governance, and return arrangements sustain the relevant source conditions. A commercial system can likewise compensate contributors while remaining extractive if the arrangement systematically weakens practical exit, control, or future generative capacity. Monetary payment is therefore one possible component of return rather than a sufficient test.

Proposition 17.113 (Generative-exploitation diagnosis condition). *Within the present framework, a claim of generative exploitation in an epistemic system should identify the materially relevant contribution or generative condition, the asymmetry through which appropriation or control becomes effective, the conversion or realization pathway benefiting another position, the return and governance structure, and the connected mechanism through which the source side’s later generative capacity, options, maintenance, or practical agency are weakened.*

Proposition 17.113 also fixes the section’s evidential burden. Similarity between input and downstream output is insufficient where contribution cannot be reconstructed. Profitability is insufficient where source-side appropriation and consequence are unclear. Lack of payment is insufficient where contribution was knowingly organized through a commons or gift relation. Asymmetry is insufficient without a mechanism of appropriation. Power may facilitate exploitation, but Chapter 16 requires power claims to identify how feasible action or generative possibility is conditioned. Normative conclusions about injustice require an additional evaluative argument. The concepts are connected, yet analytically non-equivalent.

Table 17.9 summarizes the principal diagnostic objects developed in this section. The rows can coexist within one empirical configuration; for example, a platform-

Table 17.9: Diagnostic architecture of generative exploitation in epistemic systems

Object	Source-side contribution	Appropriation or conversion interface	Generative consequence requiring investigation
Knowledge	Know-how, records, situated knowledge, methods, interpretation, provenance	Capture, enclosure, exclusive downstream control, conversion into proprietary or institutional assets	Loss of control, recognition, access, bargaining position, or capacity to continue generating
Attention	Reception, monitoring, engagement, behavioral response, interpretive effort	Interface design, ranking, recurrent solicitation, behavioral capture, advertising or recommendation systems	Fragmentation, exhaustion, displaced inquiry, reduced autonomy over attention allocation
Creative labor	Writing, design, code, art, problem solving, curation, critique, maintenance	Contract, platform, repository, organizational workflow, model or product integration	Weak return, deskilling, lost future opportunity, attribution loss, constrained reuse or exit
Unpaid generativity	Contributions whose value emerges through aggregation, reuse, maintenance, or downstream conversion	Commons, volunteer system, platform, institution, informal relation	Whether non-payment is voluntary and sustainable or coupled to asymmetric appropriation and depletion
Platform mediation	Data, participation, network formation, content, reviews, moderation, interaction traces	Rules, interfaces, ranking, interoperability, access control, monetization, network effects	Concentrated control, lock-in, weakened portability, opaque return, or dependency
AI mediation	Training material, feedback, prompts, annotations, evaluation, creative work, domain expertise	Data pipelines, model training, fine-tuning, evaluation, deployment, proprietary interfaces	Attribution and control changes, substitution pressure, verification burdens, dependency, recursive source depletion

mediated system can appropriate attention, creative labor, and data while simultaneously generating dependency and source-side depletion.

17.9.1 Extraction of Knowledge

Knowledge extraction is the most direct epistemic case. Section 17.1 established that knowledge can function as resource, capability, relation, infrastructure, and generative condition. Chapter 14 then treated epistemic extraction as asymmetrical appropriation of knowledge, data, attention, interpretation, experience, credibility, or related contributions under materially consequential changes in control, return, recognition, access, or future capacity. The present subsection narrows the object to knowledge itself and asks how an epistemic contribution can become detached from the governance conditions under which it was generated.

Information differs from many ordinary commodities because disclosure can permit repeated use while leaving the original representation physically intact, and be-

cause its economic value is often uncertain before acquisition (Arrow 1962). These properties make knowledge diffusion socially productive in many settings. They also make extraction difficult to diagnose through physical possession. A laboratory protocol can be copied. A community's ecological knowledge can be translated into a database. A worker's tacit workaround can be standardized into organizational procedure. A user's accumulated behavioral history can be transformed into a predictive feature. In each case, the source may retain some form of the original knowledge while downstream control, scale of application, convertibility, and return change substantially.

The first diagnostic task is provenance. A knowledge claim should identify who or what materially contributed to the resulting epistemic object and through which process. Provenance can be individual, collective, institutional, historical, infrastructural, or mixed. Many epistemic products depend on inherited public knowledge, prior scholarship, shared language, education, standards, software, instruments, local experience, and current labor. A complete provenance account is often impossible, but the relevant material contributors should be represented to the level required by the research problem. Otherwise, a downstream holder can appear to be the sole generator of a capacity whose actual production was distributed across a wider field.

The second task concerns appropriation. Appropriation can operate through exclusive legal rights, secrecy, organizational control, contractual restrictions, database enclosure, technical incompatibility, platform rules, credentialing, or practical control over the interface through which knowledge becomes economically actionable. The existence of one of these mechanisms does not establish exploitation. The analysis asks whether the mechanism enables one position to realize value from materially contributed knowledge while altering the source position's return, options, maintenance conditions, or later capacity.

The third task concerns conversion. Epistemic contributions can be converted into financial revenue, institutional authority, reputation, proprietary capability, administrative control, predictive capacity, or access to other resources. Typed conversion matters because the contribution and the realized return may occur in different value forms. A community can contribute ecological knowledge while an external organization receives regulatory authority or commercial revenue. Employees can contribute process knowledge while the organization accumulates durable routines. Researchers can produce open findings that later become components of privately controlled products. These patterns are not automatically exploitative, but the conversion interface can concentrate control over downstream realization even when source knowledge remains available.

Return should therefore be interpreted broadly. It can include payment, attribution, reciprocal access, licensing rights, shared governance, capacity building, infrastructure, data access, improved working conditions, community benefit, or preservation of future use. A narrow monetary test can miss arrangements in which contributors prefer recognition, control, access, or continued participation. Conversely, substantial payment can coexist with generative exploitation when appropriation produces durable loss of exit, control, or future generative capacity. The relevant criterion is the relationship between realized benefit and the reproduction of the source's generative conditions.

Proposition 17.114 (Knowledge-extraction return condition). *Where knowledge generated through materially relevant contribution is appropriated or converted under asymmetrical control, assessment of generative exploitation should include the source position's effective return in the value forms material to continued generation, including access, attribution, governance, capability, maintenance, and future options where these are relevant to the case.*

Proposition 17.114 keeps open knowledge and collaborative science within the analysis without presumptively classifying them as extractive. Knowledge commons can deliberately permit broad reuse and can generate further value precisely because exclusion is limited (Hess and Ostrom 2007; Benkler 2002). Their sustainability depends on governance, contribution, maintenance, recognition, and continued access rather than on exclusive ownership alone. Generative exploitation becomes a stronger possibility when reuse is coupled to asymmetrical enclosure or control that weakens the contributors or the shared conditions on which future knowledge generation depends.

17.9.2 Extraction of Attention

Attention extraction concerns the appropriation of scarce receptive, interpretive, and behavioral capacity. Section 17.4 treated attention as a finite economic capacity whose allocation is shaped by institutions, algorithms, visibility structures, and capture mechanisms. The present question concerns a narrower relation: when the recurrent capture or redirection of attention becomes part of an appropriation process that expands another position's generative capacity while weakening the source's ability to allocate, restore, or use attention for its own purposes.

Simon observed that information abundance produces scarcity of the attention required to receive it (Simon 1971). In contemporary epistemic systems, attention can be economically valuable because it enables advertising exposure, behavioral learning, network participation, sales conversion, recommendation feedback, reputation, and further data generation. The attention itself is rarely transferred like a durable object. Its economic effects arise through episodes of orientation, reception, interpretation, response, and repeated return.

A distinction is needed between attracting attention and extracting it. A lecture, book, conversation, performance, or public message can invite attention and create substantial reciprocal value. An interface can make valuable information easier to find. A platform can coordinate discovery among participants. Extraction becomes analytically salient when asymmetrical control over the conditions of attention capture systematically converts the source's receptive or behavioral capacity into downstream value while materially weakening the source's control over allocation, restoration, or future epistemic possibilities.

Several mechanisms can contribute. Recurrent notification and ranking systems can shape what becomes salient. Personalization can increase switching costs by making one interface progressively better adapted to a user's history. Social dependence can make withdrawal costly when professional or communal participation is concentrated on one platform. Behavioral data generated by attention episodes can improve future targeting, producing a recursive relation in which prior attention

helps engineer later capture. These mechanisms can be economically productive and desired by participants, so their presence alone does not establish exploitation. The stronger diagnosis requires the source-side generative consequence specified in Definition 17.112.

The source-side consequence can take several forms. Attention can become fragmented across recurrent solicitations. Long-horizon inquiry can be displaced by short-cycle responsiveness. Restorative time can be reduced. The person can lose practical visibility into why some objects repeatedly appear and others disappear. Professional or social dependency can constrain exit. These effects are empirical questions and can vary across users, institutions, and contexts. GRE therefore avoids treating measured engagement as a direct measure of extraction or harm.

Attention return is also heterogeneous. A person can receive entertainment, information, community, status, convenience, discovery, or income in exchange for attentive participation. A defensible analysis should represent these benefits alongside the appropriation mechanism. Generative exploitation concerns the historical relation between these returns and the person's future generative conditions. A system that provides immediate benefit while progressively narrowing practical alternatives or depleting sustained attention can differ materially from one that increases access, capability, and autonomous orientation over time.

Proposition 17.115 (Attention-extraction scope condition). *A claim of generative exploitation through attention requires more than evidence of high engagement or persuasive design. The analysis should identify how attention is appropriated or converted, which asymmetry makes the conversion effective, what return the source receives, and how the process is connected to materially relevant change in the source's later attention capacity, allocation control, alternatives, or generative possibilities.*

Proposition 17.115 links attention extraction to the wider chapter without reducing all attention economies to exploitation. The next subsection applies the same discipline to creative labor, where the source contribution is often more visible but the boundary between ordinary exchange and generative exploitation remains equally dependent on governance, return, and historical consequence.

17.9.3 Extraction of Creative Labor

Creative labor includes the production and maintenance of symbols, designs, arguments, code, artistic forms, classifications, models, questions, explanations, evaluations, and other epistemically consequential artifacts. Its economic significance exceeds the final artifact because creative production can also generate skills, reputations, communities, methods, datasets, styles, and future lines of inquiry. Extraction of creative labor therefore concerns more than the transfer of a completed work. It concerns the relation between the producer's generativity and the organizational or technical system that captures and converts its outputs.

Ordinary labor exchange already involves appropriation of outputs under contractual and institutional rules. GRE does not classify employment, commissioning, licensing, or publication as generative exploitation merely because another party receives value from creative work. The diagnostic question is whether asymmetrical appropriation or control of the contribution is connected to a materially relevant weakening

of the creator's later capacity, alternatives, maintenance, control, or return. Contract terms, bargaining position, attribution, portability, ownership, access to tools, career effects, and the ability to reuse or build on prior work can all matter.

Creative production is often cumulative and relational. A writer depends on language, education, editors, archives, readers, and prior texts. A software developer depends on libraries, standards, hardware, documentation, and collaborative communities. A scientist depends on institutions, instruments, colleagues, prior research, and verification systems. A designer or artist can depend on cultural repertoires and communities of practice. The resulting artifact can therefore condense a wider generative field. Exploitation analysis should avoid assigning total provenance to the most visible individual while also avoiding the opposite error of erasing identifiable creative contribution because every work has antecedents.

Maintenance work is particularly easy to underrepresent. Curation, documentation, moderation, editing, reviewing, debugging, replication, preservation, and quality control can contribute little visible novelty while sustaining the conditions under which visible creative output becomes reliable and reusable. If reward systems systematically privilege final artifacts while shifting maintenance burdens to weakly recognized contributors, generative capacity can become unevenly reproduced. This pattern can amount to exploitation when the contribution, appropriation, asymmetry, and source-side consequence are established; the existence of unequal recognition by itself remains an incomplete diagnosis.

Creative extraction can also occur through induced de-skilling. An organization can capture workers' procedures into standardized systems that later reduce the workers' discretion, bargaining position, or access to the accumulated organizational knowledge. Such standardization can simultaneously improve quality, safety, coordination, or accessibility. The evaluative result therefore depends on the full configuration. GRE's concern is the historical distribution of generative capacity: who retains the ability to understand, modify, contest, and extend the system after creative knowledge has been formalized.

Definition 17.116 (Creative-generativity appropriation). *Creative-generativity appropriation* is a process in which the outputs, procedures, styles, judgments, or accumulated know-how of creative activity are incorporated into another position's durable productive or epistemic capacity under a governance arrangement that materially changes the creator's control, return, reuse rights, alternatives, or future capacity to generate.

Definition 17.116 is descriptively broader than exploitation. Appropriation can be consensual, reciprocal, well-compensated, and capacity-enhancing. It becomes generative exploitation only when the stronger conditions in Definition 17.112 are met. This distinction is especially important for voluntary collaboration and open production, where sharing outputs can increase the generative capabilities of contributors and users simultaneously.

17.9.4 Uncompensated Generativity

Some of the most consequential epistemic contributions are unpaid or only indirectly compensated. Open-source maintenance, peer review, community moderation, pub-

lic scholarship, volunteer translation, citizen science, informal mentoring, knowledge sharing within families and communities, and contributions to knowledge commons can generate substantial value without a conventional wage or price. *Uncompensated generativity* names this descriptive condition without presuming exploitation.

That distinction is necessary because payment is neither the only form of return nor the only reason to contribute. Participants can seek learning, reputation, reciprocity, public benefit, community membership, enjoyment, moral purpose, future opportunity, or access to a shared resource. Commons-based peer production demonstrates that large-scale productive coordination can occur through arrangements that differ from conventional market pricing and managerial hierarchy (Benkler 2002). Generative-justice work likewise emphasizes the importance of circulation and participation in value flows rather than reducing justice to monetary compensation alone (Eglash 2016; Eglash et al. 2024).

The economic problem emerges when uncompensated contribution becomes a systematically relied-upon input to another position's accumulation while contributors have weak visibility into downstream use, little influence over governance, limited reciprocal access, or deteriorating capacity to continue contributing. A volunteer knowledge community can support a commercial service that returns infrastructure and improvements to the commons; another arrangement can appropriate the same commons while withholding interoperability, improvements, or meaningful return. Both involve uncompensated input, but their generative structures differ.

Within institutions, the distinction remains important. Academics may review manuscripts without direct payment because reciprocal reviewing supports a scholarly community from which they also benefit. The arrangement can become strained if review burdens expand, recognition declines, access becomes restricted, or commercial conversion grows while the conditions supporting reviewers deteriorate. Careful empirical analysis is required because individual motives and institutional returns vary, and the existence of uncompensated labor alone does not establish a single economic interpretation.

A useful diagnostic therefore asks whether the contribution remains *reproductively sustainable*. Sustainability here refers to the capacity of contributors and the supporting community to continue generating under the prevailing arrangement. Time, health, recognition, infrastructure, learning, governance voice, social reproduction, and practical alternatives can all be relevant. A system can appear efficient by treating these inputs as costless even while consuming the conditions that make them available.

Proposition 17.117 (Uncompensated-generativity distinction). *Uncompensated epistemic contribution should be treated as generative exploitation only where the contribution is materially appropriated under asymmetrical conditions and the associated return and governance structure is connected to weakening of the contributors' or source community's later generative conditions. The absence of monetary payment alone does not establish that diagnosis.*

Proposition 17.117 preserves room for gifts, commons, voluntary association, and public-service arrangements while making their maintenance conditions visible. It

also prepares the platform case, where unpaid contribution can be aggregated at scale and converted through infrastructural control.

17.9.5 Platform-Mediated Extraction

Platforms can mediate epistemic extraction because they organize interaction, access, ranking, data capture, standards, and exchange among multiple participant groups. Platform-capitalism analysis emphasizes platforms as infrastructural business forms that intermediate between users while accumulating data and benefiting from network effects (Srnicek 2016). Within GRE, the important addition is to ask how platform architecture distributes generative capacity across the positions that create content, attention, data, reputation, software, moderation, social connection, and downstream economic opportunity.

A platform can generate genuine reciprocal capacity. It can reduce search costs, connect previously separated participants, make publication easier, provide infrastructure, create markets, distribute creative work, preserve records, or support communities. These benefits can be substantial. Platform mediation becomes extractive when the interface gives one position asymmetrical control over contribution, visibility, conversion, access, or return in ways meeting the extraction criteria from Chapter 14. It becomes generatively exploitative when those mechanisms additionally weaken source-side future generativity.

Several architectural mechanisms deserve separate attention. *Rule control* determines participation, moderation, admissibility, and monetization. *Ranking control* affects visibility and therefore the practical convertibility of creative or commercial contributions. *Data control* affects who can aggregate interaction histories and convert them into predictive or strategic capacity. *Interoperability control* affects portability and switching. *Interface control* shapes how participants can reach one another and what actions are easy or difficult. *Revenue control* determines which conversions of attention or participation into financial return are available to whom. These mechanisms can coexist and need not be concentrated in one legal entity, but their configuration determines how contribution becomes appropriable.

Network effects can intensify the historical dimension. As participation grows, the platform can become more useful, which can draw further participation and accumulate more data, reputation, and complementary services. This recursive expansion can also raise exit costs when a participant's audience, social graph, reputation, archives, workflow, or customers are difficult to transfer. Section 17.8 described recursive knowledge-capital expansion; platform mediation can couple that expansion to asymmetric dependency when accumulated value is technically or institutionally non-portable.

A generative-exploitation analysis should therefore examine the counterfactual option structure available to contributors. Can they retrieve their work and records? Can they reach collaborators or audiences elsewhere? Can they understand and contest significant ranking or moderation decisions? Can downstream innovations interoperate with the accumulated knowledge base? Are changes to platform rules foreseeable and governable by affected participants? Practical answers may vary by platform and jurisdiction, so GRE treats these as empirical governance dimensions

rather than universal platform properties.

Definition 17.118 (Platform-mediated generative extraction). *Platform-mediated generative extraction* is an appropriation process in which platform-controlled rules, interfaces, rankings, data infrastructures, access conditions, or conversion channels enable value realization from participant-generated epistemic or relational contributions while materially weakening the contributors' control, return, portability, maintenance conditions, or future generative alternatives.

Definition 17.118 emphasizes architecture rather than firm type. A public, cooperative, nonprofit, or decentralized platform can also create extractive relations if its governance produces the relevant asymmetry and source-side consequence. Conversely, a commercial platform can provide extensive return, portability, governance, and capacity enhancement. Ownership form can affect the mechanism, but it does not substitute for tracing it.

17.9.6 AI-Mediated Extraction

AI-mediated epistemic systems intensify several issues already identified: large-scale aggregation of prior knowledge, conversion of human contributions into durable computational capability, opacity of some model processes, rapid reuse across domains, and changing relations between generation, verification, and attribution. Section 17.7 treated AI-mediated asymmetry as a multidimensional difference in access to models, compute, data, interpretation, verification, and institutional capacity. The present subsection asks when such asymmetries support extraction and generative exploitation.

AI systems can depend on heterogeneous human contributions across their life-cycle. These can include published texts, images, code, recorded behavior, domain expertise, annotations, preference judgments, safety evaluations, error reports, prompts, usage traces, post-deployment feedback, and maintenance labor. Some contributions are purchased under explicit contracts; some are licensed or openly shared; some arise through ordinary use of a service; some are embedded in public or institutional repositories; and some have contested or unclear governance conditions. Because these sources differ, a general claim that AI training or use is inherently extractive would exceed the framework's evidence requirements.

The first analytical task is to identify the contribution pathway. A model's output can reflect aggregate statistical learning from very large corpora, fine-tuning from narrower datasets, retrieval from external repositories, current user input, or combinations of these. Fluent symbolic output also does not by itself establish understanding, warranted knowledge, or provenance of the underlying sources (Bender et al. 2021). Generative-exploitation analysis should therefore avoid inferring direct appropriation of a particular contributor merely from apparent stylistic or semantic resemblance when the causal and provenance record is insufficient.

The second task is governance of conversion. Human-created epistemic material can be converted into model capability, organizational productivity, revenue, market position, or institutional authority. Contributors can simultaneously receive new capabilities from the resulting system: translation, coding assistance, discovery, drafting, accessibility, analysis, or lower-cost expertise. The economic relation

can therefore contain reciprocal generation alongside appropriation. The relevant question is how control over the conversion interface and the resulting capabilities is distributed.

The third task is recursive effect on source generativity. AI-mediated systems can complement creators and researchers by expanding their productive frontier. They can also alter demand for particular skills, change expectations of output volume, shift verification burdens, standardize styles, concentrate access to high-capability infrastructure, or make contributors dependent on interfaces they cannot inspect or modify. Machine-learning opacity can arise through different mechanisms, including secrecy, technical-literacy barriers, and characteristics of model scale or structure (Burrell 2016). Such opacity can matter economically when contributors or users cannot evaluate how their inputs influence downstream systems, how decisions are produced, or what alternatives remain available.

An exploitation claim therefore requires more than evidence that human-created material contributed to model capability. It should reconstruct the relation among contribution, authorization or governance where relevant, downstream appropriation, return, practical alternatives, and the source's future generative conditions. Open licensing can authorize broad reuse while leaving questions about infrastructure concentration or reciprocal return. Payment can compensate labor while leaving dependency or de-skilling unresolved. Attribution can preserve provenance while offering little governance. Each dimension should be evaluated in its own value form.

Generative-justice analysis is especially relevant when computational systems depend on distributed human and community contributions while control over the resulting infrastructure becomes concentrated. Work on computational reparations proposes circular value-flow arrangements in which value generators retain greater participation in production conditions and downstream benefits (Eglash et al. 2024). GRE interprets such proposals as one family of governance responses rather than as a universal institutional template. The underlying diagnostic question is whether the system replenishes the human and communal conditions from which its generative capacity is drawn.

Proposition 17.119 (AI-mediated exploitation condition). *AI mediation supports a diagnosis of generative exploitation when materially relevant human or shared epistemic contributions are converted into durable model, organizational, or economic capability under an asymmetry of control and the associated governance and return structure is connected to weakening of the source positions' later generative capacity, practical alternatives, maintenance, or agency. Model use, training on prior material, or capability asymmetry alone is insufficient for the stronger diagnosis.*

Proposition 17.119 also limits the scope of this subsection. Chapter 18 will examine radical human–AI asymmetry, labor substitution, abundance, distribution, and human developmental questions at greater depth. The present section remains focused on epistemic contribution and appropriation mechanisms within the knowledge economy.

17.9.7 Generative Depletion

Generative depletion concerns reduction in the conditions that support later generation. Chapter 14 already distinguished depletion from extraction: a system can lose future generative capacity through neglect, ecological damage, institutional decay, demographic change, or technological obsolescence without any identifiable beneficiary. In epistemic systems, depletion can affect skills, curiosity, attention, institutional memory, trust, interpretive plurality, verification capability, linguistic resources, archives, research communities, educational capacity, or the material infrastructure of inquiry.

The concept becomes central to generative exploitation because an appropriation process can look productive in the short run while consuming the source conditions required for future production. An organization can increase current output while exhausting expert workers. A platform can increase engagement while degrading contributors' capacity for sustained attention. A research system can maximize publication counts while weakening replication, mentoring, or long-horizon inquiry. An AI-assisted workflow can accelerate immediate production while reducing opportunities for novices to develop the tacit judgment required for later independent expertise. These are hypotheses about possible mechanisms rather than universal consequences; empirical cases can also show reinforcement, learning, and capacity expansion.

Depletion should therefore be measured relative to a specified generative function and horizon. Reduced performance on one task can coexist with expanded capability elsewhere. Automation can displace a routine skill while freeing time for higher-order work. Standardization can narrow local discretion while improving reliability and transmissibility. A community can allow some traditions to recede while generating new forms of knowledge. The evaluative question concerns which capacities matter, to whom, over what horizon, and whether substitution or regeneration is practically available.

Maintenance is the bridge between present appropriation and future capacity. Epistemic systems depend on education, mentorship, archival preservation, software maintenance, verification, peer review, community care, instrument calibration, documentation, and opportunities for exploratory learning. These functions can be underprovided when returns accrue primarily to visible outputs or downstream appropriators while maintenance costs remain with source communities or institutions. The resulting depletion can remain hidden until replacement becomes difficult or expensive.

Definition 17.120 (Epistemic generative depletion). For a specified epistemic field and historical horizon, *epistemic generative depletion* is a materially relevant reduction in the capacities, relations, infrastructures, diversity, maintenance conditions, or practical options required for later knowledge generation, interpretation, verification, preservation, or inquiry.

Definition 17.120 does not require an extractor. It becomes part of a generative-exploitation diagnosis when the depletion is connected to the appropriation process described in Definition 17.112. This distinction matters for remedy. Depletion caused by neglect may call for maintenance investment; depletion caused by extractive ap-

appropriation can additionally require changes in rights, return pathways, governance, bargaining conditions, or control over conversion interfaces.

Proposition 17.121 (Source-reproduction condition). *Where an epistemic system repeatedly relies on a source of knowledge, attention, creative labor, verification, or maintenance, assessment of long-horizon generative performance should include whether the institutional arrangement reproduces, substitutes, or depletes the source conditions required for continued generation.*

Proposition 17.121 turns source reproduction into an economic object without assuming that every source must remain unchanged. Historical systems transform. The analytical requirement is to make the transformation visible and to identify who gains new generative capacity, who loses it, whether alternatives arise, and how the burden of transition is distributed.

17.9.8 Dependency

Dependency closes the section because extraction can alter the source position even when direct depletion is limited. Chapter 16 treated dependency as a relational condition whose significance depends on the capacity at stake, alternatives, substitutability, switching costs, time horizon, and governance. In an epistemic economy, dependence can concern access to data, models, journals, platforms, credentials, languages, laboratories, proprietary standards, cloud infrastructure, search systems, archives, or expert intermediaries. Such dependence can support productive specialization and coordination. The relevant question is when appropriation processes generate or deepen dependency in ways that reinforce the asymmetry on which further appropriation relies.

Recursive dependency can arise when use of an infrastructure improves the beneficiary's knowledge capital while making the source increasingly reliant on the same infrastructure. A creator can accumulate audience and reputation on a platform that simultaneously becomes harder to leave. An organization can externalize technical expertise to a vendor and progressively lose internal verification or modification capacity. A researcher can rely on a proprietary database whose classifications and coverage become indispensable to a field. An institution can automate decisions around a model while reducing the human capability needed to contest or replace it. These pathways can create genuine efficiencies while changing the practical distribution of exit and substitution capacity.

Dependency becomes especially important when it changes bargaining over return. A contributor who can shift to alternative infrastructures can contest unfavorable conditions more effectively than one whose audience, archives, credentials, workflow, or community are locked into a single interface. The same formal right to exit can therefore have different practical meaning across positions. Economic analysis should represent the cost of rebuilding accumulated relations and knowledge, not merely the availability of another nominal provider.

The relation between dependency and exploitation is bidirectional. Extraction can produce dependency by weakening alternatives or concentrating complementary assets. Dependency can then enable further extraction by reducing the source's bargaining position or ability to refuse downstream uses. This feedback can stabilize

an exploitative configuration without requiring continuous direct coercion. Yet dependency alone remains insufficient for the diagnosis: public infrastructure, professional specialization, shared standards, and trusted institutions can create deep dependence while increasing participants' generative capacity and practical security.

Definition 17.122 (Exploitative epistemic dependency). *Exploitative epistemic dependency* is a historically reproduced condition in which a source position's practical access to epistemically consequential capabilities, audiences, infrastructures, or conversion channels becomes materially contingent on a controlling position or interface, and that dependency sustains an appropriation process that weakens the source's return, alternatives, maintenance conditions, or future generative capacity.

Definition 17.122 makes the feedback mechanism explicit. It also allows governance interventions to be analyzed at several points: portability, interoperability, shared standards, alternative infrastructures, rights to retrieve records, collective bargaining, reciprocal access, provenance, benefit sharing, maintenance obligations, public options, commons governance, and institutional capacity building. The appropriate mechanism depends on the source of dependency and the value forms at stake.

The section's overall architecture can now be stated compactly. Knowledge, attention, creative labor, and other epistemic contributions can enter systems that expand collective or organizational capability. Some contributions are paid, some reciprocated through non-monetary forms, some intentionally shared, and some weakly governed. Generative exploitation arises only when asymmetrical appropriation or control is connected to source-side weakening of return, alternatives, maintenance, or future generativity. Generative depletion records one possible consequence; dependency records one possible relational stabilization mechanism; neither is synonymous with exploitation. This preserves the diagnostic discipline established in Proposition 14.23 while extending it to the recursive epistemic economies developed in this chapter.

The transition to Section 17.10 follows from that distinction. Exploitation mechanisms operate through concrete organizational and institutional arrangements, but a diagnosis of exploitation does not by itself explain why particular schools, universities, research institutes, libraries, publishers, platforms, funding bodies, or standards systems take the forms they do. Section 17.10 therefore turns from appropriation mechanisms to the institutional architectures through which knowledge is generated, certified, preserved, distributed, financed, and transformed.

17.10 Knowledge Institutions

Section 17.9 examined epistemic systems at the level of appropriation, depletion, and dependency. The present section shifts the analytical level from particular extraction mechanisms to the durable institutional configurations through which epistemic activity is organized across time. Its objective is to specify how schools, universities, research institutes, libraries and archives, publishers, platforms, funding bodies, and evaluation systems organize the generation, transmission, preservation, validation, circulation, and allocation of knowledge-related capacities. The discussion treats these institutions as heterogeneous arrangements of roles, rules, routines, resources,

infrastructures, interfaces, and legitimating practices. The method is relational and functional: each institution is considered through the epistemic functions it stabilizes, the selection mechanisms it creates, the resources on which it depends, the relations through which it coordinates participants, and the consequences those arrangements can have for later generative possibilities.

The term *institution* is used here more broadly than a formally incorporated organization. A university can be an organization, yet the institution of peer review extends across publishers, disciplines, professional associations, funders, and research communities. Schooling likewise involves organizations while also depending on credentialing rules, curricular conventions, professional roles, public finance, family relations, and labor-market recognition. Chapter 12 treated institutions as economic structures that condition positions, relations, feasible actions, and value processes. The epistemic case adds an important temporal dimension: institutions can retain practices and capacities beyond the participation of particular persons, thereby stabilizing intergenerational transmission and historically extended inquiry.

Definition 17.123 (Knowledge institution). A *knowledge institution* is a sufficiently durable configuration of roles, rules, routines, resources, infrastructures, and recognition relations that organizes one or more epistemic functions, including generation, learning, interpretation, preservation, validation, circulation, access, evaluation, or the allocation of epistemic opportunity.

Definition 17.123 is intentionally functional and relational. It permits schools and archives to count as knowledge institutions without requiring them to perform the same tasks, and it permits a single organization to contain several institutional logics. Durability also remains scalar. A temporary research consortium can develop institutional features when rules, roles, repositories, evaluation procedures, and continuing expectations persist long enough to condition later participation. Conversely, a legally permanent organization can lose epistemic institutional capacity if routines, personnel, access arrangements, or infrastructures cease to support its stated functions.

A knowledge institution can support generativity while also creating exclusion, dependence, inertia, or capture. Institutional function and institutional quality therefore require separate evaluation. Schools can expand literacy while reproducing unequal access to advanced learning. Universities can protect long-horizon inquiry while concentrating credentialing authority. Archives can preserve traces while historical selection shapes what remains reconstructible. Funding systems can make difficult inquiry possible while narrowing the range of questions considered fundable. Standards can improve comparability while encouraging reactive adaptation to indicators. Institutional analysis consequently requires both a function profile and a mechanism profile.

Proposition 17.124 (Institutional function multiplicity). *Within an epistemic economy, the consequences of a knowledge institution should be evaluated through the configuration of functions, selection rules, resource dependencies, access conditions, and historical effects it sustains; institutional type alone does not determine epistemic or generative performance.*

Table 17.10 summarizes the principal institutional configurations considered be-

Table 17.10: Functional architecture of selected knowledge institutions

Institutional configuration	Dominant epistemic functions	Principal selection interfaces	Generative issue for investigation
Schools	Foundational learning, capability formation, socialization, orientation, credential preparation	Curriculum, admission, tracking, assessment, language, teacher allocation	Distribution of durable learning capacity and later inquiry opportunity
Universities	Advanced learning, research, credentialing, disciplinary reproduction, preservation, public engagement	Admission, hiring, promotion, curriculum, peer recognition, degree rules	Coupling among teaching, inquiry, recognition, autonomy, and long-horizon generation
Research institutes	Concentrated inquiry, mission-oriented research, laboratory continuity, specialized expertise	Programme design, recruitment, portfolio choice, project review, external sponsorship	Continuity of difficult inquiry under resource and mission dependence
Libraries and archives	Preservation, description, retrieval, access, provenance, intertemporal memory	Acquisition, appraisal, cataloguing, retention, access policy, metadata	Which traces and resources remain discoverable and reconstructible through time
Publishers	Selection, certification, editing, dissemination, attention allocation, record stabilization	Editorial screening, peer review, publication format, pricing, indexing	Conversion of research into visible and citable records and associated selection effects
Platforms	Search, ranking, recommendation, hosting, interaction, coordination, distribution	Interface design, algorithms, moderation, interoperability, data access	Mediation of visibility, participation, dependence, and epistemic reach
Funding institutions	Resource allocation, agenda support, portfolio formation, temporal protection, legitimacy	Eligibility, calls, review criteria, budgets, reporting, renewal	Upstream shaping of feasible questions, time horizons, and institutional dependence
Standards and evaluation	Comparability, verification, accountability, certification, quality signaling	Metrics, rankings, accreditation, benchmarks, review protocols	Behavioral adaptation to evaluative categories and preservation of plural epistemic aims

low. The categories overlap. Universities contain libraries and publishing functions; platforms can host archives; funding organizations can operate research institutes; schools can become sites of research and community knowledge production. The table therefore identifies dominant functions rather than mutually exclusive organizational classes.

17.10.1 Schools

Schools occupy an early and recurrent position in the epistemic economy because they organize the formation of capacities through which later knowledge can be

accessed, interpreted, questioned, and used. Economic analysis of education has long examined schooling as investment in acquired productive capacities, including knowledge and skill (Becker 1964). GRE retains that insight while broadening the analytical object. Schooling can also alter linguistic access, interpretive repertoires, confidence in inquiry, familiarity with institutions, capacity to verify claims, and the ability to participate in later epistemic relations. These effects connect directly to the multidimensional scarcity described in Section 17.2.

The economic role of a school therefore exceeds the transfer of a predetermined stock of information. A school organizes repeated relations among learners, teachers, curricula, assessment systems, peer groups, families, public authorities, technologies, and future credentialing institutions. Through these relations, it can influence which kinds of questions become intelligible, which forms of evidence become familiar, which languages or symbolic systems become usable, and which trajectories appear realistically available. Some effects are immediately measurable through learning outcomes or credentials; others emerge over longer horizons through later inquiry, occupational mobility, civic participation, or the capacity to learn again under changing conditions.

A generative analysis should distinguish at least three educational functions. The first is *transmission*: access to accumulated knowledge, techniques, languages, and practices. The second is *capacity formation*: development of abilities that permit later interpretation, verification, problem formation, communication, and further learning. The third is *orientation*: formation of expectations about what deserves attention, what counts as a legitimate question, and which domains appear available for participation. These functions can reinforce one another, yet their distributions need not coincide. A system can transmit extensive curricular content while leaving weak capacity for independent inquiry, or cultivate strong inquiry capacity while providing uneven access to inherited bodies of knowledge.

Definition 17.125 (Educational epistemic capacity). *Educational epistemic capacity* is the historically accumulated capability, supported through educational relations and institutions, to access, interpret, evaluate, generate, communicate, and continue learning from epistemic objects and practices across relevant contexts.

This concept preserves heterogeneity. Literacy, mathematical reasoning, experimental practice, historical interpretation, linguistic competence, craft knowledge, collaborative inquiry, and judgment can contribute in different combinations. Educational capacity is also relational: its practical realization depends on libraries, teachers, digital systems, communities, workplaces, research institutions, and opportunities for continued use. Treating schooling as a knowledge institution therefore directs attention to the downstream environments in which educational capacities remain active, decay, or acquire new functions.

Selection is equally important. Admission, tracking, curriculum differentiation, assessment, teacher allocation, language policy, disability accommodation, geographic access, and household resources can change who encounters which bodies of knowledge and with what continuity. The resulting inequalities can become cumulative because later opportunities often presuppose earlier capacities. Section 17.8 described this phenomenon as intergenerational knowledge advantage at a broader scale. Schools are one institutional site through which such advantage can

be reduced, reproduced, or transformed.

17.10.2 Universities

Universities combine several epistemic functions within a single institutional configuration: advanced education, research, credentialing, professional formation, disciplinary reproduction, preservation, scholarly communication, and forms of public engagement. This multiplicity distinguishes the university from a simple teaching organization or research producer. Its economic significance lies partly in the coupling among these functions. Students can enter research environments; researchers can transmit frontier knowledge through teaching; libraries and laboratories can support both inquiry and education; disciplinary communities can reproduce methods and standards while also contesting them.

The coupling is historically variable. Some universities emphasize undergraduate teaching, others research, professional education, regional service, or particular disciplinary missions. Institutional analysis therefore benefits from treating the university as a family of configurations rather than a singular organizational form. Murmann's historical analysis of knowledge, industrial development, educational institutions, and national institutional conditions illustrates how knowledge-producing organizations can coevolve with technological and economic structures rather than operate as isolated sources of ideas (Murmann 2003). Collaborative research can likewise locate consequential learning across organizational networks rather than within a single institution (Powell et al. 1996).

University autonomy deserves particular care. Long-horizon inquiry often requires temporal protection from immediate commercial, political, or administrative demands. University autonomy remains relational: universities depend on public budgets, tuition, philanthropy, grants, labor markets, professional recognition, infrastructure, regulation, and social legitimacy. The analytical question concerns the configuration of dependencies and the mechanisms through which they affect feasible inquiry. Section 17.10.7 returns to this issue from the perspective of funding institutions.

Credentialing creates another layer. Degrees can signal acquired capacities and authorize entry into occupations or further study. They can also concentrate gate-keeping authority when access to valued positions becomes strongly coupled to institutional credentials. GRE therefore distinguishes the university's contribution to capability formation from the conversion of credentials into social or economic standing. The two can be connected while remaining analytically separate.

Proposition 17.126 (University function-coupling condition). *The generative consequences of a university depend partly on how its teaching, research, credentialing, preservation, recognition, and public-facing functions are coupled; strengthening one function can support, leave unchanged, or constrain another according to the institutional mechanisms connecting them.*

Proposition 17.126 cautions against using a single output indicator as a proxy for institutional generativity. Publication volume, graduate earnings, citation impact, patenting, student numbers, selectivity, or reputation can each describe a dimension. Their relation to broad epistemic capacity depends on what activities they induce,

what they omit, and how they interact with institutional time horizons. The later discussion of standards and evaluation formalizes this concern.

17.10.3 Research Institutes

Research institutes organize concentrated inquiry around fields, missions, infrastructures, populations, technologies, or long-horizon programmes. Their forms range from public laboratories and mission agencies to independent institutes, corporate research organizations, hospital-based centres, observatories, and international research facilities. The common epistemic feature is the stabilization of specialized inquiry beyond the duration of a single project or individual researcher.

This stabilization can occur through laboratories, datasets, experimental organisms, instruments, technical staff, tacit routines, field sites, longitudinal cohorts, software, archives, or accumulated problem histories. Section 17.8 treated these durable arrangements as possible components of knowledge capital. The institutional perspective adds governance: who determines research portfolios, how continuity is financed, which risks are acceptable, what evidence counts as progress, and how accumulated capacities remain accessible to later researchers.

Research institutes are especially important where the minimum viable scale of inquiry exceeds the resources of an individual investigator. Particle accelerators, long-term ecological observations, population cohorts, astronomical observatories, high-containment laboratories, language corpora, or large computational systems require coordination and maintenance across time. Their generativity can therefore depend on preserving organizational memory and technical capability even during periods when immediate results are uncertain.

Public research funding acquired a particularly visible institutional role in the twentieth century. Vannevar Bush's 1945 report *Science: The Endless Frontier* argued for continuing public support of basic research and for an institutional structure capable of supporting research and scientific training beyond wartime mobilization (Bush 1945). The historical model has since diversified considerably, yet it illustrates the broader point: research capability can be produced through institutions that pool resources and protect inquiry horizons unavailable through isolated market transactions.

Mission concentration also creates trade-offs. A sharply defined institute can accumulate deep expertise and infrastructure, while its agenda may become dependent on sponsor priorities or inherited programme categories. Interorganizational collaboration can mitigate some limits by linking complementary knowledge and capabilities (Powell et al. 1996). It can also create new coordination costs and dependencies. Research-institute analysis should therefore reconstruct both internal continuity and external resource relations.

Definition 17.127 (Institutional inquiry continuity). *Institutional inquiry continuity* is the capacity of an organization or institutional configuration to preserve and renew the personnel, practices, infrastructures, records, and problem histories required for a line of inquiry to remain viable across changes in individual membership and project cycles.

Institutional inquiry continuity differs from preservation of a fixed research agenda. A generative institute may retain enough memory and capability to revise its questions, methods, and boundaries. Continuity supplies a temporal substrate for transformation rather than requiring intellectual stasis.

17.10.4 Libraries and Archives

Libraries and archives organize the intertemporal availability of epistemic resources. Their importance becomes clearest when knowledge is treated as historically situated rather than instantaneously accessible. Discovery depends on acquisition, appraisal, description, preservation, cataloguing, indexing, metadata, legal access, physical or digital storage, and continuing institutional maintenance. A document that once existed can become practically absent when these relations fail.

Libraries and archives perform related but non-identical functions. Libraries commonly organize access to published or otherwise collected resources across users and domains. Archives place stronger emphasis on records, provenance, evidential context, appraisal, and the preservation of traces generated through particular activities or institutions. The distinction varies across settings, and many contemporary systems combine functions. For GRE, the central point is that preservation and access are active institutional processes rather than passive storage.

Schwartz and Cook emphasize the role of archival selection, description, preservation, and communication in shaping social memory (Schwartz and Cook 2002). This observation is directly relevant to historical re-epistemization in Section 17.11 and Section 17.12. What future investigators can reconstruct depends partly on earlier decisions about what was retained, how it was described, and under what conditions it can be accessed. Absence from an archive can consequently reflect historical selection as well as absence from the underlying social world.

Libraries also possess infrastructural characteristics. Shared collections, catalogues, repositories, reading spaces, authentication systems, preservation services, and professional expertise can support heterogeneous downstream uses that the institution cannot fully specify in advance. Frischmann's demand-side account of infrastructure is useful here because shared inputs can enable diverse productive and social activities whose value emerges through later use (Frischmann 2012). Open-science policy similarly emphasizes accessible scientific knowledge and open infrastructures as components of a broader epistemic system (UNESCO 2021).

Proposition 17.128 (Intertemporal epistemic continuity condition). *The future usability of inherited knowledge depends on more than physical persistence of records; it also depends on preservation, provenance, description, discoverability, interpretive context, access arrangements, and the institutional capacity to maintain or reconstruct those relations through time.*

This proposition explains why digitization alone does not settle preservation. File formats, metadata, authentication, legal rights, storage integrity, software dependencies, language, cataloguing, and institutional memory can each affect whether a digital object remains intelligible and usable. Section 17.11 develops these underlying systems as epistemic infrastructure, while Section 17.12 returns to preservation and re-epistemization directly.

17.10.5 Publishers

Publishers organize a consequential interface between knowledge generation and public or disciplinary visibility. In scholarly settings, publishing can combine editorial selection, peer review coordination, formatting, dissemination, indexing, version stabilization, archiving, rights management, and reputation. These functions transform manuscripts and other research outputs into durable and discoverable records. The transformation is institutionally important because later research, evaluation, hiring, funding, and public debate often operate through published representations rather than direct access to the full generative process that produced them.

Finite publication capacity generally requires some form of selection, and its mechanisms matter. Editorial scope, reviewer availability, novelty criteria, language, format, business models, disciplinary expectations, and perceived audience can shape what enters the visible record. Franco, Malhotra, and Simonovits found substantial publication differences between strong and null results in a known population of social-science experiments, illustrating how research outcomes can become differentially visible before they enter the published literature (Franco et al. 2014). The example does not imply a universal publication mechanism; it demonstrates that the published record can reflect selection processes in addition to the underlying distribution of research findings.

Publisher institutions also influence access. Subscription models, publication charges, licensing, repository permissions, and indexing arrangements affect who can retrieve published work and under what conditions. These access relations connect publishers to the knowledge-scarcity analysis of Section 17.2 and to the commons analysis of Section 17.15. Open-science frameworks seek to expand availability and reuse while preserving legitimate requirements for quality, privacy, attribution, and sustainable infrastructure (UNESCO 2021).

Peer review is usefully treated as an institutionalized evaluation relation with a different analytical role from a truth criterion. It can expose errors, improve argumentation, and coordinate disciplinary judgment. It also operates under finite reviewer attention, uneven expertise, conflicts of interest, and field-specific conventions. Nosek and colleagues' Transparency and Openness Promotion framework illustrates one institutional strategy for aligning journal policies with reproducibility and openness goals through explicit standards (Nosek et al. 2015). The broader lesson is that publication practices can be redesigned through coordinated rules rather than treated as fixed properties of scholarship.

Proposition 17.129 (Publication-record mediation). *A published literature is an institutionally mediated record of epistemic activity whose composition reflects generation, submission, selection, review, revision, access, indexing, and preservation processes; evidential use of that record should therefore distinguish underlying inquiry from the mechanisms governing its visibility and durability.*

17.10.6 Platforms

Digital platforms have become major knowledge institutions because they increasingly mediate search, discovery, publication, discussion, collaboration, recommen-

dation, reputation, and access. Their epistemic role extends beyond hosting content. Interfaces and ranking systems help determine which objects become visible, which contributors encounter one another, how quickly materials circulate, what interaction data are retained, and which forms of participation are legible to evaluation systems.

Platform economics emphasizes coordination across participant groups and the importance of cross-side relations (Rochet and Tirole 2003). Contemporary platform analysis also draws attention to data extraction, network effects, and infrastructural control (Srnicek 2016). In an epistemic setting, these properties can affect more than commercial exchange. A search platform can influence discoverability; a scholarly network can affect reputation and collaboration; a repository platform can determine interoperability; a learning platform can structure sequence and feedback; a generative-AI interface can mediate access to accumulated knowledge while simultaneously introducing new verification dependencies.

Section 17.4 distinguished algorithmic attention from attention itself. The same discipline applies here. Platform mediation can alter visibility while leaving belief and action underdetermined. Users, institutions, professional norms, external search tools, direct communication, and alternative repositories can modify or counter platform effects. The strength of a platform's epistemic influence therefore depends on mechanisms such as default settings, switching costs, network concentration, interoperability, ranking opacity, data access, and the availability of credible alternatives.

Definition 17.130 (Epistemic platform). An *epistemic platform* is a digital or hybrid institutional configuration that mediates interactions among multiple participant positions and epistemic objects through shared interfaces, rules, data structures, or ranking mechanisms, thereby conditioning discovery, participation, circulation, evaluation, or access.

The definition includes commercial and non-commercial systems. A public repository can function as an epistemic platform when it coordinates depositors, users, metadata, preservation, and access. A commercial service can perform similar coordination under different governance and revenue structures. The institutional question concerns how control rights, interoperability, funding, moderation, ranking, and data relations shape downstream epistemic possibilities.

17.10.7 Funding Institutions

Funding institutions operate upstream in the epistemic economy by converting financial and political resources into feasible inquiry. Public research councils, ministries, philanthropic foundations, universities, firms, international organizations, mission agencies, and community funds can all perform this role. Their significance arises because many questions require protected time, equipment, personnel, travel, data, participant compensation, long-term maintenance, or organizational continuity before knowledge can be generated at all.

Funding therefore does more than reward completed knowledge. Calls for proposals, eligibility rules, review criteria, allowable costs, duration limits, matching requirements, reporting systems, renewal procedures, and portfolio priorities can influence which questions become practicable. Bush's postwar proposal for organized

public support of basic research is historically important precisely because it treated funding architecture as a condition for sustained scientific capability rather than as a sequence of purchases of already-defined outputs (Bush 1945). Contemporary funding systems are more diverse, yet the upstream logic remains relevant.

Resource dependence introduces a second dimension. Organizations depend on external environments for consequential resources, and those dependencies can shape organizational behavior and interorganizational relations (Pfeffer and Salancik 1978). Applied to epistemic institutions, the central analytical concern is how external funding dependence is structured. A diversified funding portfolio, stable core support, short project grants, contract research, philanthropic endowment, and single-sponsor dependence create different time horizons and bargaining positions.

Definition 17.131 (Funding-induced epistemic orientation). *Funding-induced epistemic orientation* is the change in feasible inquiry, attention, timing, organizational capacity, or problem selection produced through the eligibility rules, resource allocations, review procedures, duration structures, and renewal expectations of a funding configuration.

The definition remains descriptive. Funding-induced orientation can support neglected problems, long-horizon research, replication, infrastructure, or high-risk inquiry. It can also narrow portfolios through synchronized priorities or administrative burdens. The evaluative question depends on the relevant goals, alternative funding arrangements, distribution of opportunity, and the consequences for epistemic diversity and continuity.

Portfolio design is therefore a generative problem. A funding institution allocates scarce resources under uncertainty about future results. Immediate expected output is one consideration, alongside option creation, capability maintenance, diversity of approaches, public need, neglected domains, infrastructure, and the possibility that valuable questions have weak short-term signals. Section 17.5 showed why question formation itself can require protected conditions; funding institutions are one mechanism through which such protection can become economically real.

17.10.8 Standards and Evaluation

Standards and evaluation systems coordinate knowledge institutions by making heterogeneous activities more comparable, reviewable, and governable. Accreditation rules, citation indicators, rankings, peer-review procedures, reproducibility standards, research ethics requirements, data-management protocols, curricular benchmarks, and professional certifications can each reduce uncertainty for particular purposes. They can also redistribute attention and resources because evaluated actors adapt to the categories through which they are observed.

The value of standardization depends on the object and purpose. Common metadata can improve interoperability. Shared reporting rules can make resource use auditable. Reproducibility standards can make research materials more inspectable. Ethical protocols can protect participants and clarify responsibilities. At the same time, a standardized measure can omit dimensions that remain important for generativity, especially where quality is multidimensional or effects emerge over long horizons.

Espeland and Sauder's analysis of rankings demonstrates the reactivity of public measures: evaluated organizations can change behavior in response to the measures themselves, and commensuration can reorganize expectations and practices (Espeland and Sauder 2007). The result is analytically significant even when no manipulation occurs. Once a measure influences resource allocation, status, or organizational strategy, it becomes part of the system it describes. Chapter 5's discussion of performative representation provides the broader epistemic background for this mechanism.

Open-research standards illustrate a potentially constructive form of reactivity. The framework proposed by Nosek and colleagues uses journal and organizational policies to create explicit levels of transparency and openness (Nosek et al. 2015). The aim is to alter incentives and practices so that materials, data, procedures, and replication become more visible. This example shows why evaluation cannot be assessed only through measurement accuracy: standards can be designed to generate practices as well as record them.

Proposition 17.132 (Evaluation-reactivity condition). *When an evaluative standard is connected to consequential recognition, resources, access, or organizational decisions, the standard can become a generative condition of the behavior it measures; evaluation should therefore be analyzed jointly as representation, selection mechanism, and possible source of institutional adaptation.*

A plural evaluation architecture can reduce dependence on any single proxy, although plurality alone does not guarantee adequacy. Multiple indicators can reproduce a shared blind spot or create larger administrative burdens. The relevant design question concerns whether the evaluation portfolio preserves visibility of important but heterogeneous functions, including teaching, maintenance, replication, preservation, public engagement, infrastructure, and long-horizon inquiry.

17.10.9 Institutional Transformation

Knowledge institutions change as technologies, social expectations, economic structures, legal regimes, and epistemic practices change. Institutional transformation can be incremental, as when libraries revise metadata standards, or discontinuous, as when a new communications infrastructure reorganizes publication and access. It can involve changes in organizational boundaries, professional roles, funding relations, evaluation practices, ownership, or the distribution of tasks between humans and machines.

A generative perspective treats institutional change through its consequences for future capacity as well as its immediate efficiency. Digitization can expand access while creating software and preservation dependencies. Platformization can reduce coordination costs while concentrating interface control. AI systems can accelerate search, drafting, coding, translation, and analysis while shifting verification burdens and changing demand for particular forms of expertise. Open-science reforms can expand reuse and collaboration while requiring sustainable repositories, governance, privacy protections, and new forms of recognition. UNESCO's open-science framework is instructive because it treats accessible knowledge, infrastructures, collaboration, and engagement as interconnected institutional components rather than a single

publication rule (UNESCO 2021).

Institutional transformation is also path dependent. Existing buildings, repositories, professions, legal rules, funding commitments, disciplinary identities, and technical standards shape which reforms are feasible and which costs are displaced onto participants. Coevolutionary analysis is therefore useful: technologies, organizations, and supporting institutions can change together, with reciprocal influence rather than one-way technological determination (Nelson 1994). This point becomes especially important in Chapter 18, where AI capabilities interact with education, research, evaluation, and organizational structures.

Definition 17.133 (Generative institutional transformation). A *generative institutional transformation* is a change in roles, rules, resources, infrastructures, interfaces, or governance that materially alters an institution's capacity to support later learning, inquiry, preservation, verification, participation, or the creation of further epistemic possibilities.

The definition remains descriptive with respect to desirability. A transformed institution can become more generative for one position while reducing autonomy, access, diversity, or maintenance capacity elsewhere. Evaluation therefore requires typed effects and specified positions. Relevant questions include which capacities expand, which dependencies deepen, who gains access, what becomes easier to preserve or verify, which forms of work disappear, and whether the transformed arrangement can reproduce the conditions on which its generativity depends.

The institutional analysis developed in this section also reveals a deeper substrate. Schools depend on classrooms, languages, networks, devices, curricula, and records. Universities depend on laboratories, repositories, computing systems, standards, and communication networks. Archives depend on preservation technologies and metadata. Publishers and platforms depend on indexing, identity systems, file formats, protocols, and storage. Funders depend on application, review, accounting, and reporting systems. These cross-cutting arrangements are not reducible to the organizations that use them. Section 17.11 therefore turns from knowledge institutions to *epistemic infrastructure*: the shared technical, informational, organizational, and relational substrates through which epistemic activity becomes possible across institutional boundaries.

17.11 Epistemic Infrastructure

Section 17.10 examined knowledge institutions as durable configurations of roles, rules, routines, resources, and recognition relations. The present section moves one analytical layer downward to the shared substrates on which many such institutions and practices depend. Its objective is to specify the economic organization of data, archives, compute, communication networks, language, standards, verification systems, preservation systems, access arrangements, and observation systems insofar as these substrates support repeated epistemic activity across heterogeneous users and organizations. The method is functional and relational. Each infrastructural form is analyzed through the epistemic operations it makes possible, the complements required for effective use, the maintenance and interoperability relations on which

continuity depends, and the governance mechanisms through which access, revision, and failure are distributed.

Infrastructure is especially important for GRE because its value frequently arises through downstream uses that remain partly unspecified when the infrastructure is created. Frischmann's demand-side account emphasizes that infrastructure resources can support a wide range of productive and social activities whose value emerges through later use (Frischmann 2012). The epistemic case adds further complications. A database supports research through connected identifiers, metadata, provenance, software, permissions, and interpretive competence. A standard's coordinating effect depends on implementation and revision capacities. A computational facility can expand analytical capacity while concentrating dependence on hardware, energy, expertise, and institutional access. Epistemic infrastructure is therefore treated here as a configuration of enabling relations in which equipment is one component among several.

Definition 17.134 (Epistemic infrastructure). *Epistemic infrastructure* is a comparatively durable configuration of material, technical, informational, organizational, linguistic, and relational components whose recurrent use supports the generation, interpretation, verification, transmission, coordination, preservation, or reconstruction of knowledge across more than one immediate epistemic task.

Definition 17.134 extends the infrastructural role introduced in Section 17.1.4. The emphasis here is on the configuration required to keep that role operative. A dataset alone can be a resource. A maintained system of identifiers, schemas, documentation, repositories, permissions, software, and institutional responsibilities can make successive datasets comparable and reusable. A language can be a medium of immediate communication, while shared terminology, translation practices, reference works, educational systems, and professional conventions can function infrastructurally across generations of inquiry. The same object can therefore occupy resource, capital, institutional, and infrastructural roles at different scales.

Infrastructure also differs from institution. An institution organizes roles and authoritative expectations; infrastructure supplies recurrent capacities and interfaces on which many institutional arrangements may depend. The distinction is relational rather than absolute. A library is a knowledge institution, while its catalogues, repositories, authentication systems, preservation services, metadata standards, networks, and professional routines can also operate as infrastructure for universities, firms, public agencies, and independent researchers. Some infrastructures are governed by institutions, and some institutions become infrastructural because other actors build recurrent practices around them.

Table 17.11 summarizes the principal infrastructural forms considered below. The rows identify dominant functions rather than mutually exclusive systems. A contemporary archive depends on data formats, networks, standards, language, compute, preservation, and access governance; a verification system can depend on all of them simultaneously.

Proposition 17.135 (Infrastructure complementarity condition). *The epistemic capacity supplied by an infrastructure depends on the configuration of complementary components that make its outputs interpretable, accessible, maintainable, and usable;*

Table 17.11: Functional dimensions of epistemic infrastructure

Infrastructural form	Principal epistemic function	Central economic and governance issue
Data	Structured retention and linkage of observations or traces	Legibility, provenance, quality, reuse, and control over data-generation conditions
Archives	Intertemporal preservation of records and contexts	Appraisal, description, reconstructibility, retention, and historical visibility
Compute	Execution of analytical, simulation, search, and generative procedures	Capacity, complementarity, cost, concentration, energy, and technical dependence
Networks	Communication, discovery, coordination, and distributed access	Connectivity, interoperability, bottlenecks, resilience, and positional inequality
Language	Shared representation, interpretation, translation, and conceptual transmission	Inclusion, translation cost, standardization, semantic loss, and linguistic authority
Standards	Comparability, compatibility, measurement, classification, and coordination	Revision authority, lock-in, boundary effects, and distribution of compliance costs
Verification infrastructure	Checking, replication, audit, provenance, and contestation	Independence, capacity, transparency, incentives, and corrective pathways
Preservation infrastructure	Long-term continuity of records, software, metadata, and context	Maintenance, migration, redundancy, custody, and future intelligibility
Access governance	Allocation of rights and practical entry to shared epistemic systems	Eligibility, pricing, permissions, interoperability, accountability, and repair
Observation infrastructure	Production of recurrent records about ongoing activity	Observability, category construction, surveillance, reactivity, and performative feedback

expansion of one component can therefore yield limited generative benefit when complementary capacities remain absent or inaccessible.

Proposition 17.135 provides a discipline for the subsections that follow. More data can have little value without documentation or verification. More compute can have limited research effect without suitable data, models, skills, and access. More connectivity can intensify noise or dependency when discovery and trust mechanisms are weak. Preservation can retain files while losing the software or language required to interpret them. Infrastructure should therefore be evaluated through the relations that keep a capability usable rather than through a single capacity indicator.

17.11.1 Data

Data infrastructure organizes the production, retention, description, linkage, transformation, and retrieval of observations or traces. Contemporary economies generate data through censuses, surveys, administrative systems, transactions, sensors, scientific instruments, platforms, machines, and ordinary digital activity. The World Bank's data framework treats public-intent data as a heterogeneous ecosystem that includes administrative, survey, census, citizen-generated, and machine-generated sources, while emphasizing governance and reuse alongside collection (World Bank 2021). OECD work on data-driven public sectors similarly emphasizes institutional capacities that allow data to inform policy, service delivery, management, and inno-

vation (Ooiijen et al. 2019). These accounts support a central GRE point: data acquire infrastructural significance when recurrent arrangements make them usable across activities and time.

A data record is produced through a chain of decisions. Someone or some system determines what counts as an observation, which entities receive identifiers, how events are timestamped, what categories are available, how missingness is encoded, which transformations are permitted, and how provenance is retained. These choices influence later analytical possibility. A relation that lacks a stable identifier can be difficult to follow longitudinally. A category that changes definition without documented versioning can create false continuity. A dataset stripped of contextual metadata can remain technically accessible while becoming difficult to interpret responsibly.

The FAIR principles provide one influential formulation of data stewardship through findability, accessibility, interoperability, and reusability (Wilkinson et al. 2016). GRE treats these qualities as economically consequential because they affect the conversion of recorded traces into later epistemic capacity. Interoperability can allow multiple organizations to connect observations; reusable metadata can reduce repeated interpretation costs; persistent identifiers can support provenance and citation; access arrangements can widen or restrict who can participate in downstream inquiry. FAIRness, however, does not settle substantive questions of privacy, representativeness, ownership, justice, or appropriate use. It describes important infrastructural properties while leaving broader governance questions open.

Documentation is therefore part of data infrastructure. Datasheets for datasets were proposed as a way to document motivation, composition, collection processes, preprocessing, uses, distribution, and maintenance of datasets, especially in machine learning (Gebru et al. 2021). The broader principle applies beyond machine learning: data become more epistemically usable when their production history remains inspectable. Documentation can reveal boundary conditions and known limitations, support later verification, and reduce the risk that an operational record is mistaken for a neutral observation of the underlying world.

Definition 17.136 (Data legibility chain). A *data legibility chain* is the connected set of classifications, identifiers, collection procedures, metadata, transformations, provenance records, and interpretive conventions through which recorded traces become usable as evidence for a later epistemic task.

The definition emphasizes that data value depends on continuity across several transformations. Breakage at one point can reduce the usefulness of the whole chain. A well-measured observation can become difficult to reuse if provenance is missing; excellent metadata can have limited effect when access is revoked; broad access can still produce misleading inference when the underlying sampling frame excludes relevant populations. Data abundance therefore remains compatible with infrastructural scarcity.

Data infrastructure can also concentrate control. Organizations that operate large data-generating systems may possess access unavailable to researchers, public authorities, communities, or affected persons. This can create the epistemic asymmetries analyzed in Section 17.7. The relevant economic issue concerns more than pos-

session of records. It includes control over collection interfaces, schemas, identifiers, retention, linkage, querying, export, and the terms under which alternative actors can verify or contest a data-based representation.

17.11.2 Archives

Archives provide infrastructure for intertemporal reconstruction. Section 17.10.4 considered archives as institutions; the present subsection isolates the infrastructural relations that make archival records usable across time. These include appraisal, provenance, description, arrangement, storage, cataloguing, digitization, access controls, conservation, format migration, contextual documentation, and professional expertise. The archived object is therefore only one component of a larger reconstruction system.

Archival infrastructure is selective because preservation begins before storage. Records are generated unevenly across organizations and populations; some are destroyed or never collected; appraisal determines what enters custody; description shapes discovery; access rules condition later visibility. Schwartz and Cook emphasize that archives participate in the making of social memory through such processes (Schwartz and Cook 2002). Bowker and Star likewise show how classification infrastructures organize what becomes visible and actionable within information systems (Bowker and Star 1999). The epistemic consequence is that absence from an archive can have several meanings, including nonoccurrence, nonrecording, destruction, exclusion, failed preservation, or failed discovery.

Historical reconstructibility depends on preserving relations around the record. A memorandum without date or author, a dataset without codebook, a photograph without location, a model without version history, or an administrative record without the governing classification may retain content while losing a substantial part of its evidential context. Archival infrastructure therefore supports future inference partly by preserving provenance and relational position. This becomes especially important when later investigators use categories different from those of the original institution.

Definition 17.137 (Archival reconstructibility). *Archival reconstructibility* is the degree to which preserved records, provenance, descriptive context, relationships, and access conditions allow later investigators to reconstruct the conditions under which a record was generated and to evaluate its relevance under changed questions or interpretive frameworks.

Archival reconstructibility is compatible with interpretive plurality. Preserved context can support several later interpretations, and richer provenance and alternative descriptions can support future re-epistemization by allowing later investigators to revisit earlier classifications. This prepares the more direct treatment of preservation and re-epistemization in Section 17.13.

Archives also face economic trade-offs. Preservation consumes space, labor, energy, storage, conservation expertise, migration effort, legal review, and security. Selection can therefore reflect finite capacity as well as political and institutional priorities. Digitization can widen access while creating new dependencies on software, vendors, file formats, authentication, and network continuity. A robust archival econ-

omy requires attention to both the value of retained traces and the continuing cost of keeping them intelligible.

17.11.3 Compute

Compute becomes epistemic infrastructure when recurrent computational capacity supports analysis, simulation, search, storage, inference, model training, visualization, verification, and machine-assisted generation across multiple tasks. Its economic significance has expanded with the historical growth of computing capacity and with the increasing role of computational methods in science, administration, and production. Computer simulation, for example, can mediate relations among theory, models, data, experiment, and evidential judgment in ways that differ from both analytical derivation and direct experimentation (Winsberg 2010). Contemporary AI intensifies this dependence because frontier model development and deployment can require highly concentrated combinations of specialized hardware, data centers, energy, software, technical labor, and capital (Stanford Institute for Human-Centered Artificial Intelligence 2026).

Effective computational capacity extends beyond processor count and depends on hardware, memory, storage, network bandwidth, software stacks, libraries, model architectures, data pipelines, security, energy supply, cooling, technical support, scheduling systems, and user competence. A research group can possess theoretical expertise yet remain unable to execute a computational programme because the complementary infrastructure is unavailable. Conversely, abundant compute can produce little epistemic value when the problem formulation, data, models, or verification procedures are weak.

The distribution of compute changes the feasible set of inquiry. Larger or faster systems can allow higher-resolution simulation, larger search spaces, more extensive model ensembles, repeated robustness checks, or the training of computational models inaccessible at smaller scale. These possibilities create an economic distinction between ideas that are intellectually conceivable and inquiries that are operationally executable. The resulting asymmetry can matter for publication, commercial development, policy analysis, and the ability to verify claims produced by better-resourced actors.

Definition 17.138 (Compute-mediated epistemic capacity). *Compute-mediated epistemic capacity* is the practically available ability to execute computational operations relevant to an epistemic task, given the joint configuration of hardware, software, data, energy, networks, technical competence, scheduling access, and institutional permission.

This definition separates nominal computational resources from usable capacity. A supercomputer can exist while access queues, software incompatibility, data-transfer limits, export controls, organizational rules, or missing expertise prevent effective use. Cloud services can lower entry costs for some users while generating dependency on proprietary interfaces, pricing, geographic availability, or contractual conditions. Public or shared facilities can broaden access while still requiring allocation rules under scarcity.

Compute also raises verification problems. A result can become difficult to re-

produce when the required hardware, proprietary model, software environment, or training data are unavailable. Computational opacity can arise from model complexity as well as from institutional secrecy. Section 17.11.7 therefore treats verification capacity as a distinct infrastructure whose quality must be assessed separately from computational scale.

17.11.4 Networks

Networks connect dispersed epistemic actors, resources, instruments, repositories, and institutions. Their infrastructural functions include communication, discovery, authentication, data transfer, remote access, collaboration, citation, coordination, and distributed computation. Network infrastructure is partly technical, including internet connectivity, protocols, addressing systems, identity services, and data links, and partly organizational, including professional communities, collaborative arrangements, and trusted channels through which knowledge moves.

The economic value of connectivity depends on the structure of connection. A researcher connected to a high-speed network but excluded from relevant repositories can remain epistemically isolated. A laboratory with rich local capacity can lose access to collaborators when identity or interoperability systems fail. A professional network can transmit tacit knowledge and opportunities unavailable through formal publications. Studies of interorganizational collaboration show that innovation can be distributed across networks of learning and extend across organizational boundaries (Powell et al. 1996). The infrastructural implication is that some epistemic capability resides in patterned access to others rather than within a single node.

Networks can reduce distance while creating bottlenecks. Search engines, indexing services, identity providers, domain registries, scholarly databases, cloud platforms, and communication services can become high-centrality interfaces through which many downstream interactions pass. Their failure or policy change can therefore propagate widely. Technical redundancy and organizational plurality can increase resilience, while fragmented standards can reduce interoperability. Network design consequently involves trade-offs among efficiency, openness, security, decentralization, and continuity.

Proposition 17.139 (Epistemic connectivity condition). *The epistemic value of a network connection depends on the resources, permissions, protocols, trust relations, and complementary capacities reachable through that connection; connection count alone provides an incomplete measure of usable epistemic reach.*

Proposition 17.139 matters for economic analysis because apparent digital inclusion can coexist with large differences in effective participation. Bandwidth, language, institutional credentials, subscription rights, computational compatibility, accessibility design, and social recognition can each shape what a connection makes possible. Network infrastructure should therefore be evaluated through reachable capabilities and dependencies together with physical connectivity.

17.11.5 Language

Language functions as epistemic infrastructure when shared vocabularies, grammars, terminologies, translation practices, reference systems, and educational conventions support recurrent interpretation across persons and institutions. Section 17.2.5 treated linguistic access as one dimension of knowledge scarcity. The infrastructural perspective asks how languages and specialized symbolic systems organize the field through which knowledge can be expressed, searched, compared, transmitted, and recognized.

A shared language can reduce coordination costs by stabilizing terms and enabling participation in distributed inquiry. Scientific nomenclatures, legal vocabularies, statistical classifications, programming languages, controlled vocabularies, and disciplinary concepts provide more specialized infrastructures. They allow highly compressed communication once participants acquire the relevant competence. The same compression can create entry barriers because the meaning of a term depends on histories of use, tacit distinctions, genre conventions, and institutional training.

Language also carries power. Bourdieu's account of language and symbolic power emphasizes that linguistic exchanges occur within social relations that confer unequal legitimacy on speakers and forms of expression (Bourdieu 1991). GRE therefore distinguishes communicative possibility from recognized epistemic standing. A person may possess relevant knowledge yet face translation costs, accent discrimination, limited publication access, or disciplinary conventions that make the contribution difficult to recognize. Conversely, a standardized professional language can facilitate international collaboration while narrowing the range of locally embedded concepts that travel easily.

Translation is an infrastructural operation involving more than lexical substitution. Concepts can have partial equivalents, historically specific connotations, or domain-specific meanings. Translation systems, bilingual corpora, dictionaries, terminological databases, interpreters, and multilingual education can widen epistemic access, but translation can also produce semantic compression or false equivalence. Chapter 7's methodological caution concerning translation between representations applies here at institutional scale: successful coordination may require preserving remainders that resist complete translation.

Definition 17.140 (Linguistic epistemic infrastructure). *Linguistic epistemic infrastructure* is the historically maintained configuration of languages, terminologies, translation practices, reference resources, educational capacities, and recognition conventions through which epistemic content becomes expressible, interpretable, searchable, and socially receivable across positions.

This definition helps explain how multilingualism can function as an economic capability within knowledge systems. It can enlarge the set of accessible archives, communities, conceptual traditions, legal materials, and collaborative relations. The generative effect depends on actual translation and interpretive capacity, however, rather than the nominal presence of several languages in an institution.

17.11.6 Standards

Standards stabilize interfaces. Measurement units, metadata schemas, accounting conventions, taxonomies, citation formats, identifiers, calibration procedures, file formats, quality protocols, and technical specifications can allow heterogeneous actors to compare, combine, exchange, and verify epistemic objects. Their infrastructural value is often greatest when they recede into the background and become part of ordinary coordination. Bowker and Star show how classifications and standards become embedded in information infrastructures while carrying social and historical consequences (Bowker and Star 1999). Porter's history of quantitative objectivity similarly demonstrates how standardized procedures can support forms of impersonal trust and administrative comparability (Porter 1995).

Standards can lower repeated negotiation costs. Shared identifiers allow records to be linked; common units allow measurements to be compared; metadata schemas allow repositories to exchange records; calibration standards allow instruments to produce commensurable observations. The resulting interoperability can expand the generative use of existing resources because combinations become feasible that were previously costly or unreliable.

Standardization also redistributes adaptation costs. Existing practices that fit the standard can become easier to scale, while alternative practices may need translation or redesign. Early adoption can create path dependence when organizations invest in compatible systems. Revision can then become expensive even when a superior technical arrangement becomes available. The economic analysis of standards therefore concerns the distribution of benefits, switching costs, revision authority, and the treatment of cases that fit poorly.

Definition 17.141 (Epistemic interoperability). *Epistemic interoperability* is the practical capacity of heterogeneous records, instruments, models, systems, or institutions to exchange and combine epistemic objects while preserving enough semantic, procedural, and provenance information for the resulting use to remain interpretable.

Interoperability is stronger than technical compatibility. Two datasets can share a file format while using incompatible concepts. Two institutions can use the same indicator while deriving it through different populations or procedures. Two models can exchange outputs while assigning different meanings to the underlying variables. Standards therefore support epistemic coordination only when syntactic compatibility is accompanied by adequate semantic and procedural alignment.

Standards are also revisable institutions embedded in infrastructure. Governance matters because revision determines which users bear migration costs, whose use cases are represented, how backward compatibility is handled, and whether alternative implementations remain feasible. The design of revision procedures can therefore affect both resilience and concentration of infrastructural authority.

17.11.7 Verification Infrastructure

Verification infrastructure supplies recurrent capacities for checking epistemic claims, processes, and artifacts. It includes replication procedures, audit trails, provenance systems, peer review, calibration, benchmark datasets, test suites, sta-

tistical diagnostics, preregistration, version control, code review, model evaluation, data documentation, and institutional pathways for correction. Section 17.3.5 identified verification as a scarcity under epistemic abundance. The present subsection asks what material and organizational arrangements expand that scarce capacity.

Open-research initiatives illustrate the infrastructural dimension. The Transparency and Openness Promotion guidelines propose standards for data, code, research materials, design, preregistration, and replication in scholarly communication (Nosek et al. 2015). Large replication projects have also treated reproducibility as an empirical property subject to investigation (Open Science Collaboration 2015). These efforts do not create a single universal verification method. They show that verification can require shared protocols, repositories, documentation, incentives, and labor beyond the original production of a result.

Verification capacity is domain-specific. Experimental replication, archival source criticism, mathematical proof checking, software testing, qualitative triangulation, model auditing, and administrative review rely on different evidential practices. Methodological pluralism therefore applies to verification infrastructure. The common feature is the presence of pathways through which claims can be examined by actors other than the original producer or by the producer under conditions that expose relevant error.

Definition 17.142 (Verification infrastructure). *Verification infrastructure* is the maintained configuration of records, protocols, tools, expertise, access arrangements, and corrective procedures through which epistemic claims or artifacts can be independently or comparatively examined relative to the standards appropriate to their domain.

Independence should be interpreted carefully. Complete social or technical independence is often unavailable because verifiers may share instruments, datasets, software, classifications, or professional assumptions. A useful verification pathway introduces enough procedural, evidential, or analytical variation to expose relevant failure modes in the original production process. A software test generated from the same erroneous specification can reproduce the error consistently. A second statistical analysis using the same biased administrative data can confirm the same artifact. Verification infrastructure therefore benefits from pathway diversity where the relevant risk justifies it.

Computational systems make this issue especially visible. Consequential algorithms can require technical and institutional procedures for accountability that ordinary inspection of a human decision would not provide (Kroll et al. 2017). Access to logs, model versions, documentation, test environments, or audit interfaces can determine whether scrutiny is practically possible. Verification thus connects directly to access governance and epistemic power.

17.11.8 Preservation Infrastructure

Preservation infrastructure maintains epistemic usability across time. It includes storage, redundancy, checksums, conservation, migration, emulation, format documentation, metadata, version histories, repositories, backup systems, custody arrangements, legal permissions, and the labor required to keep these components

connected. Preservation differs from immediate archiving because the relevant time horizon extends beyond current software, institutions, personnel, and interpretive conventions.

Digital abundance can obscure preservation fragility. Copying a file is inexpensive relative to preserving its future intelligibility. A model may depend on libraries that cease to run; a database may rely on proprietary software; an interactive visualization may require a discontinued browser environment; a corpus may lose its license documentation; an encrypted archive may outlive the keys required for access. Physical media also degrade, and organizational custody can disappear through merger, insolvency, conflict, or institutional reorganization.

Open-science policy recognizes preservation and stewardship as components of sustainable epistemic systems (UNESCO 2021). FAIR principles similarly connect reuse to metadata and stewardship rather than storage alone (Wilkinson et al. 2016). GRE extends this concern by treating preservation as a generative investment in future option space. Preserved records can support questions that were not anticipated when the material was created. Their future value therefore cannot always be estimated from present demand.

Definition 17.143 (Preservation continuity). *Preservation continuity* is the maintained capacity to keep epistemic objects sufficiently authentic, interpretable, discoverable, and accessible across changes in media, software, institutions, personnel, and interpretive context.

Preservation continuity is a process rather than a one-time act. It can require periodic migration, repair, documentation, re-description, rights review, and reconstruction of obsolete environments. These activities consume resources without necessarily generating visible new outputs. Evaluation systems focused on immediate publication or innovation can therefore underweight preservation labor even when later inquiry depends on it.

Redundancy can improve resilience, but preservation design also involves governance. Multiple copies under one legal or technical authority can remain vulnerable to a common failure. Geographic, institutional, technological, and custodial diversity can reduce some correlated risks while increasing coordination cost. Section 17.13 will examine preservation choices more directly through provenance, alternative interpretations, negative results, historical context, and preservation cost.

17.11.9 Access Governance

Infrastructure becomes epistemically consequential through rules of practical access. Access governance determines who can enter, query, download, modify, contribute to, audit, interconnect with, or revise a shared epistemic system and under what conditions. These rules can be legal, contractual, technical, financial, organizational, professional, or social. A repository can be publicly funded yet require institutional credentials. A dataset can be nominally open while demanding specialized compute. A standard can be publicly documented while implementation depends on proprietary components. Effective access is therefore a layered capability.

Access governance differs from ownership. Section 17.8 distinguished ownership,

control, and access within knowledge capital. Infrastructure adds a recurrent and collective dimension. One actor can own a component while another operates it, a standards body governs interoperability, public agencies fund maintenance, and dispersed users create much of the downstream value. Commons scholarship is useful because shared knowledge resources can involve differentiated bundles of participation, contribution, exclusion, and governance across public, private, cooperative, and mixed arrangements (Hess and Ostrom 2007; Schlager and Ostrom 1992).

Pricing is one among several access mechanisms. Eligibility rules, identity verification, geographic restrictions, export controls, institutional affiliation, licensing, rate limits, interface design, disability access, language, data-use agreements, security clearance, and review procedures can each shape participation. These mechanisms can protect privacy, safety, sustainability, or scarce capacity. They can also reproduce asymmetry when affected positions lack alternative routes or meaningful contestation.

Definition 17.144 (Epistemic access-governance profile). An *epistemic access-governance profile* specifies the rights, permissions, prices, eligibility conditions, technical interfaces, contribution rules, revision powers, appeal pathways, and continuity guarantees through which positions can use or influence a shared epistemic infrastructure.

The profile makes visible a distinction between use access and governance access. A person may be allowed to read a database while having no ability to correct an error concerning them. Researchers may query a platform through a restricted interface while lacking access to sampling logic or historical versions. Developers may implement a standard while having little influence over its revision. These arrangements distribute epistemic agency differently even when nominal access appears broad.

Access governance also concerns failure and repair. Infrastructure users can become dependent on interfaces whose withdrawal would interrupt research, education, business, or public services. Notice periods, portability, interoperability, archival export, service-level commitments, and appeal procedures can therefore affect exit capacity and resilience. The economic question concerns how access conditions, legitimate constraints, maintenance obligations, and dependency are organized across affected positions, including the circumstances under which broader access, restricted access, or differentiated access is justified.

17.11.10 Observation Infrastructure and Performative Recording

Observation infrastructure produces recurrent records about ongoing activity. Censuses, surveys, administrative databases, accounting systems, sensors, transaction logs, scientific instruments, platform telemetry, monitoring dashboards, audits, and reporting requirements can make processes visible that would otherwise be difficult to reconstruct. Chapter 1 showed how contemporary data infrastructures expand relational observability while embedding classifications, measurement conventions, permissions, and institutional incentives in the production of evidence. The present subsection adds a further point: observation systems can participate in the processes they record.

Observation begins with selective inscription. A reporting system decides which

events count, which categories are available, how frequently values are recorded, and which deviations trigger review. Desrosières's history of statistical reasoning and Porter's analysis of quantitative objectivity both illustrate how statistical and numerical practices depend on conventions that make heterogeneous situations comparable (Desrosières 1998; Porter 1995). The resulting record can be highly useful while remaining a product of an organized observation regime.

Recording becomes performative when the existence or anticipated use of the record changes behavior, institutions, or the phenomenon's later trajectory. Rankings can alter organizational behavior because actors respond to publicly consequential measures (Espeland and Sauder 2007). Financial models can become incorporated into market practices and thereby contribute to reshaping the markets they represent (MacKenzie 2006). Administrative indicators can change incentives when eligibility, budgets, sanctions, or public reputation depend on recorded values. These mechanisms differ, yet each demonstrates that observation can become an epistemic event with causal consequences.

Definition 17.145 (Performative recording). *Performative recording* occurs when a system for recording, classifying, measuring, ranking, or reporting activity becomes part of the causal field of that activity because actors or institutions adjust behavior in response to the record, its anticipated production, or the consequences attached to it.

Performative recording is neither inherently beneficial nor inherently distortive. Public reporting can improve accountability, safety, comparability, and learning. Measurement can also produce gaming, category fixation, strategic concealment, or displacement toward what is easier to record. The appropriate analysis identifies the feedback mechanism, the affected positions, the time horizon, and the relation between the recorded variable and the substantive object of concern.

This feedback creates an important distinction between observation error and observation-induced change. An indicator can mismeasure a stable phenomenon, or the indicator can measure accurately at one moment and then contribute to changing the phenomenon once actors respond. These cases require different remedies. Better calibration may address measurement error. Performative change may require redesigning incentives, diversifying indicators, separating learning from sanction, or revising the governance of the recording system.

Proposition 17.146 (Observation-feedback condition). *When records influence decisions, rewards, sanctions, recognition, or expectations, analysis of an observation infrastructure should include the pathway through which recording and subsequent uptake can alter later behavior, data generation, and observability.*

Proposition 17.146 connects epistemic infrastructure to the broader GRE architecture. Observation can become internal to generative history when it changes later possibilities. A classification entered into an administrative system can influence eligibility; a citation metric can redirect research effort; a risk score can alter treatment and thereby the data later used to update the score; a preservation decision can determine which future interpretations remain feasible. Epistemic infrastructure therefore participates in the economy through both enabling capacity and historically consequential feedback.

The section as a whole establishes a substrate-level account of epistemic economy. Data, archives, compute, networks, language, standards, verification, preservation, access governance, and observation systems provide recurrent conditions for knowing without collapsing into one institutional form. Their economic significance lies in the downstream capabilities they enable, the dependencies they create, the maintenance they require, the histories they preserve, and the authority they distribute over access and revision. Section 17.12 turns from these infrastructural conditions to epistemic justice, where visibility, voice, classification, evidential resources, interpretive authority, contestability, preservation, and future re-recognizability become explicit normative objects.

17.12 Epistemic Justice

Sections 17.1–17.11 described how knowledge can function as resource, capacity, relation, infrastructure, capital, and generative condition; how epistemic abundance can coexist with verification, attention, orientation, and trust scarcity; how curiosity and aesthetic judgment orient inquiry; how epistemic asymmetries can be converted into power; how epistemic capacities accumulate; how generative exploitation can arise; and how institutions and infrastructures organize recurrent epistemic activity. The present section introduces the normative specialization required once these descriptive architectures affect economic standing, participation, burden, opportunity, and future possibility. Its objective is to identify the justice-relevant properties of epistemic relations without treating difference, expertise, scarcity, institutional authority, or unequal outcomes as sufficient evidence of injustice. The discussion proceeds through visibility, voice, classification, evidential resources, interpretive authority, contestability, preservation, and future re-recognizability. The method is relational, mechanism-sensitive, and theory-plural: GRE specifies the epistemic objects and pathways that require normative evaluation while leaving room for different moral and political theories to justify, prioritize, or contest particular standards.

Epistemic justice has an established philosophical lineage. Fricker’s account distinguishes testimonial injustice, in which prejudice can distort the credibility granted to a speaker, from hermeneutical injustice, in which unequal participation in shared interpretive resources can disadvantage people in making significant experiences intelligible (Fricker 2007). Longino’s contextual empiricism emphasizes the epistemic importance of critical interaction, uptake, and plural perspectives in scientific inquiry (Longino 1990). Relational theories of justice likewise direct attention toward standing, domination, participation, and institutional relations in addition to distributions of goods (Young 1990; Anderson 1999). GRE draws on these precedents while narrowing the present task to the economic organization of epistemic possibility. The concern is how epistemic arrangements shape who can become visible, articulate relevant knowledge, produce accepted evidence, participate in interpretation, challenge classifications or conclusions, preserve consequential records, and remain recognizable to future inquiry.

Definition 17.147 (Epistemic justice in GRE). *Epistemic justice in GRE* is the normative assessment of the terms through which economically consequential epistemic standing, visibility, voice, classification, evidential capacity, interpretive authority,

contestability, preservation, and future re-recognizability are generated, distributed, exercised, revised, and transmitted across affected positions.

Definition 17.147 is deliberately broader than a distribution of information. A person can possess information while lacking credibility, interpretive standing, evidential resources, access to a review pathway, or the institutional capacity to preserve a record. An institution can provide open data while maintaining opaque classifications or high burdens of proof. A platform can widen visibility while exposing some positions to surveillance or reducing their control over context. Epistemic justice therefore concerns the organization of epistemic relations and capabilities, including the conditions under which knowledge can become consequential.

The definition is also narrower than a complete theory of justice. Epistemic justice can conflict with privacy, safety, confidentiality, professional responsibility, due process, resource constraints, or other legitimate values. Equal epistemic influence is not an automatic requirement. Specialized expertise can justify differentiated authority; confidentiality can justify restricted access; evidential standards can appropriately exclude weak claims; and preservation can be limited by privacy or safety. The normative question concerns whether the terms of differentiation are justified relative to their purposes, burdens, effects, alternatives, accountability, and revisability.

Table 17.12 summarizes the eight dimensions developed below. The dimensions overlap without becoming interchangeable. Visibility can enable voice while also increasing exposure. Classification can structure evidential requirements. Interpretive authority can shape which evidence counts as relevant. Contestability can revise classifications or evidential judgments. Preservation and future re-recognizability extend these relations across time.

Proposition 17.148 (Epistemic asymmetry–justice non-equivalence). *An epistemic asymmetry does not by itself establish epistemic injustice. A justice claim requires additional analysis of the asymmetry’s origin, purpose, scope, conversion mechanisms, affected interests, burdens, alternatives, accountability, contestability, historical formation, and consequences for present or future epistemic agency.*

Proposition 17.148 specializes the broader asymmetry–justice discipline established in Chapter 16. The distinction is especially important in epistemic systems because unequal competence can be appropriate and socially valuable. A surgeon, archivist, engineer, statistician, translator, or domain researcher can possess specialized expertise that warrants differentiated epistemic authority within a bounded task. The justice problem arises when such differentiation is unjustifiably widened, insulated from correction, converted into status subordination, or combined with resource and institutional arrangements that prevent affected positions from contributing relevant knowledge or challenging consequential errors.

17.12.1 Visibility

Visibility is a precondition for many forms of epistemic participation, yet visibility itself is ambivalent. Section 17.4.6 treated unequal visibility as an attention-allocation problem. The present subsection asks when the terms of becoming visible are justice-relevant. An economically consequential position can be absent from administrative data, organizational dashboards, research agendas, historical records, model cate-

Table 17.12: Dimensions of epistemic justice in the epistemic economy

Dimension	Epistemic object	Principal justice question
Visibility	Entry into attention, records, models, and decision-relevant representation	Which positions, experiences, contributions, and harms become legible, and under what protections against excessive exposure?
Voice	Articulation, reception, credibility, uptake, and response	Which positions can contribute relevant knowledge or dissent through pathways capable of consequential consideration?
Classification	Categories, boundaries, identifiers, labels, and eligibility rules	How are classificatory burdens, errors, revision rights, and consequences distributed across affected positions?
Evidential resources	Data, records, expertise, methods, time, tools, and verification capacity	Which positions can produce, access, challenge, and interpret evidence under the applicable standards and burdens of proof?
Interpretive authority	Capacity and standing to assign meaning, relevance, uncertainty, and implication	How are expertise, situated knowledge, institutional mandate, affected experience, and revision obligations related?
Contestability	Challenge, review, rebuttal, correction, and reopening of epistemic claims	Which claims, classifications, models, or evidential judgments can be challenged through usable and responsive pathways?
Preservation	Retention, stewardship, contextualization, access, and deletion of epistemic traces	Which knowledge and records persist, who governs their survival, and how are preservation benefits and risks allocated?
Future re-recognizability	Later capacity to reconstruct previously obscured positions, contributions, harms, and interpretations	Can future inquiry revisit present classifications and judgments with enough trace, context, and provenance to recognize what earlier systems missed?

gories, publication systems, or institutional attention. It can also become intensely visible through monitoring, profiling, ranking, or surveillance. Epistemic justice therefore concerns both under-visibility and overexposure.

Honneth's analysis of social invisibility distinguishes physical perception from socially meaningful recognition (Honneth 2001). This distinction is useful for GRE because a subject or activity can be recorded without being recognized in a form that affects claims, resources, or institutional response. Care work can appear in time-use data while remaining weakly represented in compensation or organizational design. A community can be extensively measured while its interpretation of the measurements carries little authority. A worker can be highly visible to productivity monitoring while invisible in the categories through which maintenance burden, stress, or tacit contribution are assessed.

Visibility is therefore relational and purpose-dependent. The relevant questions include what becomes observable, by whom, through which categories, with what resolution, under whose control, and with what consequences. A visibility arrangement can support justice when it makes previously obscured burdens, harms, contributions, or needs actionable. It can undermine justice when exposure is imposed asymmetrically, when contextual information is stripped away, when visibility increases vulnerability, or when visibility serves control without corresponding avenues for

explanation and challenge.

Definition 17.149 (Epistemic visibility profile). An *epistemic visibility profile* records, for a specified object and institutional setting, which positions, events, contributions, burdens, and claims can become observable and representable; the categories and infrastructures through which visibility is produced; the authorities able to access or act on the resulting representation; and the protections, omissions, exposures, and response pathways attached to that visibility.

Definition 17.149 prevents visibility from being treated as a scalar good. More visibility can improve recognition in one relation while increasing exposure in another. Epistemic justice can therefore support selective legibility: enough visibility for relevant claims and harms to become actionable, combined with governance over purpose, access, contextual integrity, retention, and downstream use.

17.12.2 Voice

Voice concerns the capacity to contribute experience, observation, interpretation, warning, criticism, proposal, or dissent to an epistemic process that can receive and consider it. Chapter 16 analyzed voice as a governance function connected to participation and contestability. The present subsection narrows the object to epistemic standing and uptake. A person can possess a formal opportunity to speak while lacking credibility, translation support, conceptual vocabulary, evidential access, or a channel through which the contribution can alter the epistemic state of the institution.

Fricker's concept of testimonial injustice provides a specific model of how credibility can be distorted by identity prejudice (Fricker 2007). GRE retains the mechanism while widening the economic setting. Credibility can also be shaped by occupational status, institutional affiliation, educational credentials, platform ranking, language, technical format, organizational hierarchy, or access to recognized evidential forms. These factors are not inherently illegitimate. Credentials can communicate competence and institutional roles can allocate responsibility. Justice analysis asks whether credibility structures track relevant reasons with sufficient openness to correction, or whether they systematically discount some positions beyond what the epistemic purpose justifies.

Voice also has a resource dimension. Articulating a consequential claim can require time, language proficiency, documentation, legal or technical assistance, emotional safety, access to data, and persistence through repeated procedures. Equal formal speaking rights can therefore coexist with sharply unequal epistemic voice. Conversely, specialized channels can increase effective voice by providing translation, representation, protected reporting, expert mediation, or formats adapted to different forms of knowledge.

Definition 17.150 (Epistemic voice capacity). *Epistemic voice capacity* is the situated practical capacity of a position to formulate a relevant epistemic contribution, transmit it through an accessible and sufficiently protected channel, receive epistemically appropriate consideration, and obtain a response or revision pathway proportionate to the significance of the contribution.

The definition does not require acceptance of the contribution. A just epistemic process can reject testimony, evidence, or interpretation when reasons support rejection. The relevant distinction is between reasoned non-acceptance and systematic inability to enter the process on usable terms. Epistemic voice concerns the conditions under which contribution can become a candidate for responsible uptake.

17.12.3 Classification

Classification converts heterogeneous situations into categories that can be stored, compared, governed, funded, insured, researched, ranked, or made eligible for institutional action. Section 17.11.6 treated standards and classifications as infrastructural coordinators. The justice question concerns the incidence of their boundaries and the institutional consequences attached to them. Bowker and Star show how classifications and standards organize information infrastructures while carrying social and practical consequences that can become difficult to see once categories are embedded in routine systems (Bowker and Star 1999).

Economic classifications can determine whether work counts as employment, whether a condition meets an eligibility threshold, whether an activity appears in national accounts, whether a research output is legible to an evaluation system, whether a household fits an administrative category, or whether a platform account is identified as risky. These classifications can perform necessary coordination. Their justice profile depends on how boundary cases are treated, what errors cost, which positions bear documentation burdens, whether categories encode historically sedimented assumptions, and how revision occurs when categories cease to fit their objects.

Classification also shapes epistemic possibility upstream. If a data system lacks a category for a phenomenon, later analysis can have difficulty detecting it. If categories are imposed before affected positions can articulate their experience, the resulting records can reproduce the initial conceptual limitation. Fricker's account of hermeneutical injustice is relevant here because unequal participation in shared interpretive resources can make some experiences difficult to render intelligible in socially recognized terms (Fricker 2007). GRE extends the concern to the infrastructures through which classifications become economically operative.

Proposition 17.151 (Classification-justice condition). *Where a classification materially affects access, recognition, burden, evidence, opportunity, or institutional response, its epistemic-justice profile should include the basis of the categories, the treatment of boundary and uncertain cases, the distribution of documentation and error costs, the participation of affected knowledge, and the availability of revision when the classification becomes misleading or harmful.*

Proposition 17.151 is compatible with specialized criteria in taxonomy, diagnosis, scientific measurement, accounting, regulation, and other institutional domains. Its requirement is that consequential classification be analyzed as a governed epistemic act whose criteria, boundaries, incidence, and revision pathways can be examined.

17.12.4 Evidential Resources

Epistemic participation depends on resources for producing, accessing, evaluating, and challenging evidence. These resources include records, data, instruments, documentation, archives, computational capacity, methodological expertise, time, funding, translation, legal discovery, verification systems, and access to relevant witnesses or sites. Section 17.11 analyzed many of these as infrastructure. Epistemic justice asks how their distribution interacts with evidential standards and burdens of proof.

An evidential standard can be reasonable while remaining practically inaccessible to some positions. A worker may be asked to document a harm using records controlled by the employer. A community may be required to demonstrate environmental exposure using monitoring systems it does not possess. A small research group may face replication or documentation requirements that are appropriate in principle while lacking the infrastructure available to a large institution. These cases should not be collapsed into one conclusion. Sometimes the standard should remain and access to evidential resources should improve. In other cases the standard itself may require revision because it privileges evidence generated by one institutional position while discounting other reliable forms of knowledge.

The economic importance of evidential resources also extends to verification scarcity. Section 17.3.5 showed that abundant claims can increase the relative importance of checking capacity. When verification tools, provenance systems, experts, or data access are concentrated, some positions can bear far higher costs in establishing a claim or contesting an error. Evidential inequality can therefore become a pathway through which formal rights or nominal access lose practical value.

Definition 17.152 (Evidential-resource capability). *Evidential-resource capability* is the practical capacity of a position to obtain, generate, preserve, interpret, verify, and present evidence of the types reasonably relevant to a consequential epistemic or institutional claim, taking account of the applicable standards, burdens, time horizon, infrastructure, and access conditions.

Definition 17.152 treats practical conversion capacity as its central object. Two positions can nominally access the same database while differing greatly in compute, language, expertise, legal permission, time, or capacity to interpret it. Epistemic justice therefore requires attention to the conditions that convert formal availability into usable evidential capacity.

17.12.5 Interpretive Authority

Evidence does not determine its own significance. Interpretation assigns relevance, context, uncertainty, causal implication, normative salience, and relation to competing explanations. Section 17.7.2 described interpretive asymmetry as a descriptive difference in the capacity to make sense of information. The present subsection asks when the allocation and exercise of interpretive authority become justice-relevant.

Interpretive authority can arise from expertise, professional responsibility, institutional mandate, lived experience, local knowledge, custodial relation, historical position, or control over a recognized interpretive forum. These sources of standing can overlap while pointing in different directions. Technical experts can un-

derstand model behavior that affected users cannot inspect. Affected users can understand contextual consequences that model designers cannot observe from aggregate data. Archivists can understand provenance structures unfamiliar to later researchers. Community members can possess historically situated meanings that external analysts would reconstruct poorly. A just epistemic arrangement need not flatten these forms of knowledge into equal authority; it should specify which type of interpretation is relevant to which object and how disagreements can be examined.

Longino's account of critical interaction is useful because it treats objectivity as supported by social conditions under which assumptions and interpretations can encounter criticism (Longino 1990). GRE uses this insight institutionally. Interpretive authority becomes more robust when the scope of authority is explicit, alternative perspectives can enter where they possess relevant knowledge, reasons can be articulated, and revision remains possible when evidence or context changes.

Proposition 17.153 (Interpretive authority–competence non-equivalence). *Epistemic competence can justify differentiated interpretive standing within a bounded domain. Authority extending to consequential meanings, affected experiences, institutional classifications, or downstream normative judgments requires additional justification appropriate to those objects.*

Proposition 17.153 protects specialization without granting epistemic jurisdiction by extension. A statistician's competence regarding estimation does not automatically settle the social meaning of a category. A physician's diagnostic expertise does not exhaust a patient's knowledge of lived effects. A community's experience does not automatically settle technical causal questions. Justice-sensitive interpretation therefore requires a mapping between epistemic competence, affected position, institutional mandate, and the specific question being interpreted.

17.12.6 Contestability

Contestability is the capacity to challenge consequential epistemic acts and obtain a process capable of reconsidering them. Chapter 16 analyzed contestability broadly as a governance function. Epistemic contestability focuses on claims, categories, measurements, models, evidential judgments, interpretations, and records. Its object is the revisability of the epistemic basis on which consequential decisions or institutional understandings depend.

A complaint channel provides weak epistemic contestability when the challenged evidence cannot be inspected, the classification cannot be reopened, the reviewing body lacks relevant competence, or the institution can respond without giving reasons. Effective contestability can require access to the relevant record, an intelligible explanation of how a judgment was produced, an opportunity to introduce counterevidence, an authority capable of correcting the epistemic object, and a pathway for the correction to propagate into downstream decisions. These conditions can be especially demanding in automated or model-mediated systems where the epistemic object is distributed across data, code, model versions, thresholds, institutional rules, and human interpretation.

Contestability can also support epistemic quality beyond individual remedy. Longino's account of critical interaction suggests that sustained criticism can expose

background assumptions and improve collective inquiry (Longino 1990). In GRE, contestability can operate as an institutional learning mechanism when challenges are recorded, patterns are analyzed, and repeated errors trigger revision of categories, evidence standards, or infrastructures.

Definition 17.154 (Epistemic contestability). *Epistemic contestability* is the practical capacity of an affected or relevantly situated position to challenge a consequential epistemic claim, classification, record, model, evidential judgment, or interpretation through a pathway that permits intelligible access to the contested basis, submission of relevant counterevidence or reasons, competent review, and correction or reasoned confirmation where warranted.

The definition distinguishes contestability from guaranteed success. A challenge can be rejected after adequate review. It also distinguishes epistemic contestability from general political participation. The same institution can provide extensive public consultation while maintaining weak mechanisms for correcting a specific record or model, or it can provide strong technical appeal while offering little participation in rule formation. These are different governance objects.

17.12.7 Preservation

Preservation determines which epistemic traces remain available across time. Archives, repositories, institutional records, publications, model documentation, oral histories, datasets, correspondence, and material artifacts can later support verification, reinterpretation, accountability, or recovery of neglected knowledge. Section 17.11.8 analyzed preservation as infrastructure. The present subsection asks how selective survival becomes a justice issue.

Preservation is selective by necessity. Storage, curation, migration, documentation, and stewardship require resources. Privacy, security, dignity, confidentiality, intellectual property, and legal obligations can also justify restricted retention or deletion. Epistemic justice therefore does not require maximal preservation. It asks whose traces are preserved, which categories organize them, which contexts remain attached, who controls access, which knowledge disappears through underfunding or institutional neglect, and how preservation choices affect future capacities to verify or reinterpret consequential histories.

The historical literature on archives makes this selectivity analytically visible. Trouillot analyzes how silences can enter the production of history at several stages, including source creation, archival assembly, narrative production, and retrospective significance (Trouillot 1995). Schwartz and Cook likewise emphasize that archives participate actively in the shaping of social memory through appraisal, selection, description, preservation, and access (Schwartz and Cook 2002). These arguments support a GRE treatment of preservation as a generative institutional process: preservation influences which later questions can be asked and which claims can be reconstructed.

Proposition 17.155 (Selective-preservation justice condition). *Where preservation choices can materially affect later recognition, verification, accountability, historical reconstruction, or access to accumulated knowledge, their epistemic-justice profile should include the basis of selection, stewardship responsibilities, contextual preservation, ac-*

cess conditions, deletion and privacy risks, maintenance burdens, and the distribution of consequences created by survival or loss.

Proposition 17.155 leaves room for justified forgetting. Retaining a harmful label indefinitely can reproduce stigma. Persistent personal data can create surveillance and security risks. Sensitive testimony can require restricted custody. Justice can therefore require differentiated retention, controlled access, anonymization, distributed stewardship, or deletion as well as preservation. The normative object is the governed relation between epistemic continuity and the risks carried by continued trace.

17.12.8 Future Re-Recognizability

Future re-recognizability extends preservation beyond survival of records. Chapter 16 introduced future recognizability within historical justice as the practical capacity of later inquiry to reconstruct justice-relevant economic histories from preserved and interpretable traces. The epistemic-economy formulation developed here emphasizes a further possibility: future inquiry may possess categories, methods, computational capacities, evidence, or normative concepts that are unavailable in the present. A just epistemic arrangement can therefore preserve sufficient trace and provenance for later agents to re-recognize positions, contributions, harms, relations, or interpretations that current systems fail to identify adequately.

This capacity matters because epistemic systems are historically limited. Present categories can omit phenomena that later become salient. Current evidence standards can underrepresent forms of knowledge that later methods can evaluate more effectively. Model outputs can become interpretable only after later access to training data, documentation, or version history. A community's contribution can become recognizable after provenance is reconstructed. Future re-recognizability therefore concerns preservation of conditions for later epistemic revision while acknowledging the historically bounded categories available to present institutions.

The distinction from preservation is important. A record can survive while becoming uninterpretable because metadata, context, language, software, provenance, or institutional memory have disappeared. Conversely, future recognition can sometimes be reconstructed from partial traces when later inquiry connects archives, testimony, material evidence, and alternative classifications. The relevant capacity is therefore relational: it depends on the preserved trace and on the future possibility of reconnecting that trace to context and meaning.

Definition 17.156 (Future re-recognizability). *Future epistemic re-recognizability is the practical capacity of later inquiry to identify, reconstruct, and responsibly reinterpret economically or justice-relevant positions, contributions, harms, relations, and epistemic claims that earlier systems recorded incompletely, classified inadequately, interpreted differently, or failed to recognize, using sufficiently preserved trace, provenance, contextual information, and revisable access arrangements.*

Proposition 17.157 (Future re-recognizability condition). *Where present epistemic classifications or decisions can generate durable consequences and later reassessment is reasonably foreseeable, epistemic justice provides a reason to preserve proportionate reconstructive capacity while governing privacy, security, cost, stewardship, access,*

and the possibility that preservation itself creates harm.

Definition 17.156 and Proposition 17.157 make future revision part of the epistemic-justice horizon without treating indefinite data retention as a default. The appropriate degree of reconstructive capacity depends on stakes, reversibility, historical significance, expected learning value, affected interests, and the risks of continued storage. High-stakes institutional decisions may justify stronger provenance and version retention than routine low-stakes interactions. Some personal information may warrant deletion even when retention would improve later reconstructability.

The eight dimensions developed in this section form a relational sequence without implying a fixed order. Visibility can precede voice, while voice can create new visibility. Classification can determine which evidence becomes collectible, while evidential challenge can revise classification. Interpretive authority can support coordination, while contestability can correct its overreach. Preservation can sustain institutional memory, while selective loss can render some positions historically weak. Future re-recognizability extends the justice problem across time by asking whether later inquiry retains a practical capacity to revisit present limits.

Epistemic justice in GRE therefore concerns the terms under which epistemic participation and epistemic consequence are organized. Informational differences and differentiated authority acquire a justice profile through their purposes, mechanisms, burdens, protections, consequences, and conditions of revision. GRE's distinctive contribution is to connect that normative evaluation to the mechanisms already developed in this chapter: attention, question formation, orientation, asymmetry, knowledge capital, generative exploitation, institutions, and infrastructure. The justice question becomes more precise when the analyst can identify which epistemic capability is differentiated, how that difference is converted into consequence, whose agency or standing is affected, which review and preservation pathways exist, and how the arrangement shapes later generative possibilities.

Section 17.13 continues from this normative architecture to the temporal mechanics of knowledge preservation and re-epistemization. The next task is descriptive and process-oriented: to examine how records, provenance, alternative interpretations, negative results, historical context, future reanalysis, future reinterpretation, and preservation cost condition what can actually remain available for later epistemic revision.

17.13 Knowledge Preservation and Re-Epistemization

This section develops the temporal continuity problem of the epistemic economy. Section 17.12 established preservation and future re-recognizability as possible objects of epistemic justice; the present section asks how epistemic systems can retain enough structured trace for later inquiry to verify, recombine, reanalyze, reinterpret, or contest earlier knowledge under changed conditions. The objective is to distinguish physical or digital survival of records from preservation of their future epistemic usability, and to show how that usability depends on provenance, interpretive plurality, negative-result memory, historical context, and continuing stewardship. The discussion proceeds through record preservation, provenance, alterna-

tive interpretations, negative results, historical context, future reanalysis, future reinterpretation, and preservation cost. The method is temporal and resource-sensitive: preservation is treated as an economic allocation across present and future epistemic possibilities, with retained volume evaluated through future usability, cost, risk, and stewardship.

The problem extends earlier book-wide treatments of evidence preservation in research praxis and historical re-epistemization. Those treatments established that later inquiry can revise the warranted representation of an earlier object when evidence, categories, methods, models, or evaluative standpoints change. The epistemic-economy problem is broader. Records are produced and maintained by households, firms, states, universities, archives, communities, platforms, laboratories, publishers, professional associations, and computational systems. Their preservation affects future verification, attribution, organizational memory, policy learning, historical reconstruction, intellectual inheritance, and the possibility of recovering knowledge whose relevance was not visible when the record was created.

Preservation therefore has a generative dimension. A record can support uses that its creator did not anticipate; a later method can extract structure that an earlier method could not; a new question can reconnect previously separate archives; and a later normative vocabulary can reveal consequences that earlier classifications obscured. At the same time, preservation consumes storage, labor, compute, documentation, legal review, security, migration, and attention. Some records also carry privacy, dignity, safety, or misuse risks. The economic object is consequently a governed portfolio of future epistemic options under finite resources and heterogeneous obligations.

Definition 17.158 (Epistemic preservation configuration). An *epistemic preservation configuration* is a temporally extended arrangement of records, provenance, contextual information, interpretive documentation, access conditions, technical dependencies, stewardship responsibilities, and preservation resources that maintains a specified range of future epistemic uses.

Definition 17.158 makes the target of preservation relational. A file can survive while the software required to read it disappears. A dataset can remain downloadable while its variables lose historical meaning. A model can remain executable while its training data, parameter history, or decision context becomes inaccessible. Conversely, a partial record can retain substantial epistemic value when its provenance, context, and relation to complementary sources remain reconstructible. Preservation quality therefore concerns the future relation between trace and use as well as material survival.

Table 17.13 summarizes the eight dimensions developed in this section.

17.13.1 Record Preservation

Record preservation provides a material and organizational basis for later epistemic revision. Relevant records include primary observations, correspondence, fieldnotes, administrative traces, datasets, code, model states, version histories, publications, peer-review records, decisions, classifications, oral histories, images, sensor outputs, legal documents, institutional minutes, and records of failed or abandoned work.

Table 17.13: Dimensions of knowledge preservation and re-epistemization in the epistemic economy

Dimension	Preserved relation	Future epistemic function
Record preservation	Source traces, representations, versions, and dependencies	Reconstruction, verification, recombination, and recovery
Provenance	Origin, custody, selection, transformation, and version history	Attribution, audit, interpretation, rights analysis, and error localization
Alternative interpretations	Plausible competing explanations, categories, and models	Reopening inquiry when assumptions, evidence, or concepts change
Negative results	Failed tests, null findings, rejected specifications, and unsuccessful pathways	Avoidance of repeated search cost and correction of selective epistemic memory
Historical context	Categories, institutions, incentives, technologies, and meanings surrounding a record	Historically situated interpretation and reduced presentist reconstruction
Future reanalysis	Reusable records and methodological dependencies	New analysis under changed questions, evidence, methods, or computational capacity
Future reinterpretation	Preserved meanings, disputes, concepts, and contextual relations	Revision of significance, explanation, attribution, or normative appraisal
Preservation cost	Storage, curation, migration, security, governance, and attention burdens	Selection among preservation portfolios under finite resources and heterogeneous risks

Their epistemic roles differ. Some permit verification of a published claim; others preserve context that was never encoded in the final representation; still others support later questions that could not have been formulated when the record was created.

The epistemic-economy perspective therefore distinguishes *retention volume* from *reconstructive capacity*. Retaining more bytes, pages, objects, or messages can increase reconstructive capacity, yet the relation is conditional. A vast repository with weak indexing, absent metadata, inaccessible formats, or uncertain custody can provide less usable future knowledge than a smaller collection whose records remain connected to their origins, meanings, dependencies, and access rules. Section 17.11 developed preservation infrastructure as one component of epistemic infrastructure. The present analysis focuses on the temporal option that such infrastructure can maintain.

Archival scholarship makes the selectivity of survival visible. Schwartz and Cook emphasize that appraisal, description, preservation, and access participate in the construction of social memory rather than merely storing an already complete historical world (Schwartz and Cook 2002). Trouillot similarly analyzes how silences can enter historical production through source creation, archival assembly, narrative con-

struction, and retrospective significance (Trouillot 1995). These observations imply that preservation decisions participate in future epistemic possibility. What remains available influences which later questions can be investigated, which contributions can be attributed, and which institutional histories can be reconstructed.

A record's future value can also be highly option-like. The present institution may be unable to specify the later question, method, or comparison that makes a record valuable. Unique or difficult-to-regenerate traces can therefore carry value partly because they keep future analytical pathways open. This option value is especially important for transient observations, disappearing languages, institutional states that cannot be recreated, historical datasets, extinct software environments, and records produced during one-time crises or transitions.

Proposition 17.159 (Reconstructive sufficiency condition). *An epistemic preservation configuration supports future re-epistemization only to the extent that the retained records and their dependencies remain sufficiently connected for the intended class of later inquiry to reconstruct the evidential or interpretive relation at issue.*

Proposition 17.159 permits selective retention. The relevant bundle is purpose-relative. A computational result may require code, data versions, parameters, and environment information. A historical claim may require source documents, cataloging context, provenance, and records of known gaps. A qualitative interpretation may require more contextual trace than the selected quotations appearing in publication. The economic question is which reconstructive relations justify preservation relative to cost, risk, irrecoverability, and expected future use.

Record preservation also creates temporal asymmetry. Institutions with durable repositories, stable funding, interoperable systems, and professional stewardship can transmit accumulated epistemic capacity across generations more effectively than actors whose records depend on fragile devices, proprietary services, short-term contracts, or informal memory. Preservation capacity can therefore become one mechanism through which knowledge capital and institutional advantage persist. Durable preservation can serve legitimate continuity while its unequal distribution remains an economically consequential feature of the epistemic field.

17.13.2 Provenance

Provenance preserves the history through which an epistemic object acquired its present form. For data, provenance can include collection conditions, inclusion rules, transformations, merges, missingness decisions, coding changes, model-generated additions, and version history. For documents and archives, it can include origin, custody, selection, digitization, cataloging, known omissions, and access restrictions. For computational outputs, it can include software versions, model versions, prompts or parameter configurations where materially relevant, training or reference corpora, execution environments, and consequential human interventions.

The analytical role of provenance is broader than reproducibility. It helps later inquiry identify where a property entered an epistemic chain. A discontinuity might originate in the observed object, the sampling procedure, the classification system, the translation, the cleaning process, the model, or a later aggregation. Without provenance, those possibilities can become difficult to distinguish. Documentary

methodology therefore treats origin, authenticity, production conditions, and institutional purpose as part of evidential evaluation (Scott 1990). Contemporary data stewardship similarly emphasizes metadata, provenance, interoperability, and reusability as conditions of future use (Wilkinson et al. 2016; Gebru et al. 2021).

Provenance also has economic functions of attribution and governance. When a later product or model incorporates accumulated contributions from many sources, preserved lineage can affect whether contributions are recognizable, whether licensing or access conditions can be evaluated, whether errors can be traced, and whether benefit-sharing or responsibility claims can be assessed. The relevant provenance need not be perfectly complete to be useful. Its adequacy depends on the stakes and the causal or normative question being asked.

Definition 17.160 (Epistemic provenance chain). An *epistemic provenance chain* is a documented sequence of materially relevant origins, custodial states, selections, transformations, versions, and uses through which a record, representation, model, or knowledge object reaches its current form.

The chain metaphor permits branching and converging histories because many epistemic objects are assembled from multiple sources. A dataset can merge administrative systems; a model can depend on several corpora and software libraries; an historical reconstruction can connect archives produced by different institutions. Provenance can therefore be represented as a graph or other relational structure where that representation improves reconstructability. The essential requirement is traceable dependence, not a particular data model.

Proposition 17.161 (Provenance-option condition). *Preserved provenance increases future epistemic option value when later inquiry can use the lineage information to distinguish source properties from transformation effects, reconnect separated contributions, localize error, or reassess attribution and governance relations.*

Proposition 17.161 also identifies a reason that provenance can itself require preservation investment. A repository that stores source material while discarding transformation history can preserve evidence yet lose much of its future auditability. Conversely, exhaustive event logging can create costs and privacy risks that exceed likely reconstructive value. Provenance design therefore requires materiality judgments about which transformations, versions, and dependencies are consequential enough to retain.

17.13.3 Alternative Interpretations

Epistemic systems often preserve conclusions more reliably than the space of plausible interpretations from which those conclusions emerged. Publications, policy documents, databases, and institutional records tend to stabilize one representation, category, or explanatory account. Competing interpretations can disappear even when their rejection depended on assumptions, limited evidence, disciplinary convention, or temporary practical constraints. Future inquiry then inherits an apparently settled object while losing part of the reasoning history through which settlement occurred.

Preserving alternative interpretations can reduce this form of path dependence. The relevant object is a selective record of materially plausible alternatives whose

evidential basis, assumptions, unresolved issues, or reasons for rejection could matter under later evidence or conceptual change. Longino's account of scientific objectivity emphasizes the epistemic importance of critical interaction and the exposure of background assumptions to challenge (Longino 1990). Preservation extends that critical relation through time by allowing later inquiry to recover alternatives that earlier communities considered but did not adopt.

Definition 17.162 (Interpretive plurality record). An *interpretive plurality record* is a preserved account of materially relevant alternative explanations, classifications, representations, or evaluative readings together with enough evidence, assumptions, and decision history to reconstruct why each alternative was considered, retained, modified, or rejected.

Such a record can serve several economic functions. It can lower the cost of reopening an inquiry after new evidence appears. It can reveal which assumptions drove an earlier choice. It can prevent a later organization from treating a historically contingent standard as the only conceivable representation. It can also support institutional learning when repeated disputes concern the same hidden assumption. The value lies in preserving branching points in the epistemic trajectory together with the reasons that made those alternatives consequential.

Alternative interpretations require status labels. A rejected hypothesis that failed a decisive test should not later appear equivalent to an interpretation that remained plausible but underdetermined. A speculative interpretation should remain distinguishable from one supported by substantial evidence. Preservation should therefore include the epistemic standing and reasons available at the time, while leaving room for later revision. The result is historical openness with provenance, rather than retrospective flattening of earlier debate.

This practice also limits presentism. A later vocabulary can make an earlier interpretation appear obviously inadequate even when the later categories were unavailable to the original community. Conversely, reverence for historical categories can conceal how later evidence changes what can responsibly be claimed. Preserving alternative interpretations allows both judgments to be made with greater temporal precision: what was supportable then, what became supportable later, and which assumptions account for the change.

17.13.4 Negative Results

Negative results are a special case of epistemic memory because the incentives governing their visibility can differ from the incentives governing positive or novel results. Null findings, failed replications, unsuccessful interventions, rejected model specifications, abandoned technical pathways, and hypotheses unsupported by available evidence can carry information about the boundaries of a phenomenon or the productivity of a search direction. Their disappearance can make the preserved record systematically more optimistic, more decisive, or more successful than the underlying inquiry process.

Empirical work on publication patterns provides a concrete illustration. Franco, Malhotra, and Simonovits found, in a known population of social-science experiments, that null results were substantially less likely to be written up and published

than strong results (Franco et al. 2014). Fanelli documents a broader decline in the reported proportion of negative results across many disciplines and countries (Fanelli 2012). These findings support a narrower inference: selective visibility can alter the epistemic memory from which later actors infer what has already been tried and what the evidential field looks like.

Negative-result preservation has an economic function through avoided repetition. When unsuccessful but informative attempts vanish, later researchers, firms, public agencies, or technical teams may pay again for substantially similar exploration. The loss can be especially costly when the original failure depended on hidden implementation conditions, boundary assumptions, or contextual constraints that are likely to recur. Preserving an interpretable negative result can therefore reduce future search cost even when the result never becomes part of a canonical positive theory.

Proposition 17.163 (Negative-result memory condition). *Preserving a negative result has epistemic-economic value when the record can materially reduce repeated search cost, delimit the conditions of a claim, reveal implementation or measurement constraints, support later synthesis, or correct a systematically selective representation of the evidential field.*

The proposition remains selective. Trivial failures, irreproducible mistakes without diagnostic value, and enormous volumes of exploratory output can impose curation costs larger than their foreseeable future value. A useful negative-result record should therefore preserve enough context to distinguish an informative failure from an uninterpretable absence of success. At minimum, this can include the question, design, relevant conditions, result, uncertainty, and known reasons why the attempt may have failed.

Negative results can also become positive generative resources after technological or conceptual change. A failed experiment may contain data relevant to a later question. An abandoned model can expose a structural constraint that later theory incorporates. A discontinued intervention can show which institutional dependencies were underestimated. The generative significance of the record therefore need not equal the significance assigned at the time of its creation.

17.13.5 Historical Context

Historical context preserves the relation between an epistemic object and the configuration within which it was produced. Categories, measurement standards, institutional purposes, legal rules, available technologies, disciplinary conventions, incentives, languages, and political conditions can all affect what was recorded and how it was interpreted. When these relations disappear, later inquiry can mistake a historically situated representation for a timeless description of its object.

Historical re-epistemization earlier in the book distinguished changes in evidence, categories, models, and evaluative standpoints from changes in the underlying past process. The epistemic-economy extension developed here asks what must survive for that distinction to remain reconstructible. A historical dataset can require information about changing classifications; an institutional metric can require documentation of the incentives it created; a legal category can require contemporaneous doctrine and administrative practice; an AI-generated record can require model/version

context; and an archive can require knowledge of why particular documents entered or failed to enter the collection.

Conceptual history provides one reason for this care. Koselleck analyzes historical concepts as situated within changing structures of experience and expectation rather than as invariant labels (Koselleck 2004). Classification studies similarly show that categories and standards can become infrastructural and consequential while remaining historically produced (Bowker and Star 1999). Preserving historical context therefore supports more than antiquarian detail. It helps later inquiry recover the conditions under which a category, claim, or record could have the meaning and practical effects that it had.

Definition 17.164 (Historical-context envelope). A *historical-context envelope* is the bounded set of contemporaneous classificatory, institutional, linguistic, technological, methodological, normative, and practical conditions required to interpret a preserved epistemic object without projecting materially different later conditions onto its production or use.

The envelope is deliberately bounded. Complete reconstruction of a historical world is usually infeasible. The relevant context is the subset whose absence would materially alter interpretation, attribution, or assessment. For a price series, currency regime and measurement conventions may matter more than unrelated institutional details. For a classification system, administrative purpose and eligibility consequences may be central. For a model used in a high-stakes decision, available alternatives, data access, institutional authority, and known uncertainty may be necessary to evaluate responsibility.

Historical context also protects against a converse error: allowing historical situatedness to immunize earlier claims from later criticism. Preserved context can show why a claim was reasonable under one information set while later evidence justifies revision. It can also show when evidence available at the time was ignored or when institutional incentives shaped what became visible. Context is therefore a resource for more discriminating evaluation across historically situated information sets and responsibilities.

17.13.6 Future Reanalysis

Future reanalysis occurs when later inquiry applies changed questions, evidence, methods, computational capacities, comparison sets, or classifications to preserved epistemic material. The object can be a dataset, archive, corpus, model, qualitative record, institutional history, administrative trace, or mixed collection. Reanalysis differs from exact reproduction because the later inquiry may intentionally alter the analytical frame. It uses preservation to ask something that the original analysis did not or could not ask.

Definition 17.165 (Future epistemic reanalysis). *Future epistemic reanalysis* is a later analytical operation that re-examines preserved records or representations under materially changed questions, evidence, methods, computational capacities, categories, comparison structures, or evaluative criteria while retaining sufficient provenance to distinguish the later operation from the earlier one.

Reanalysis is economically significant because it can extend the productive life of accumulated epistemic resources. A costly dataset can support questions beyond its original project. Archival digitization can enable comparisons previously impracticable. Improved computational tools can identify patterns in preserved material that earlier researchers could not process. Newly linked records can change the granularity of analysis. In this sense, preservation can raise the option value of prior epistemic investment by making recombination possible across time.

The possibility of future reanalysis also changes how present infrastructure should be evaluated. Systems optimized only for present publication can discard information required for later reuse. Conversely, preserving full raw data, every intermediate state, and every software dependency indefinitely can be wasteful or unsafe. Reanalysis capacity therefore depends on an anticipated class of future uses and on the degree of irrecoverability. The more unique the underlying observation, the stronger the case can become for preserving source-level trace and transformation history.

Reanalysis remains an inquiry whose warrant requires assessment. Later methods can introduce new biases; larger computational capacity can amplify poorly specified categories; and linkage can create false confidence when identifiers or classifications are unstable. Its distinctive value lies in reopening an object under materially changed conditions while preserving comparison with the original analysis.

17.13.7 Future Reinterpretation

Future reinterpretation concerns change in the meaning, significance, explanation, attribution, or normative appraisal assigned to preserved epistemic material. The same records can support a different interpretation when concepts change, previously marginalized testimony becomes legible, institutional histories are reconstructed, new comparative cases alter salience, or normative vocabularies develop. Reinterpretation can occur with little change in quantitative processing, and it can transform the object of inquiry more substantially than a technically sophisticated reanalysis.

Definition 17.166 (Future epistemic reinterpretation). *Future epistemic reinterpretation* is a later revision of the meaning, explanatory significance, attribution, classification, or evaluative understanding of preserved epistemic material under changed conceptual, historical, relational, or normative conditions.

The distinction between reanalysis and reinterpretation is analytically useful because the two can move independently. A historical dataset can be reanalyzed with a new statistical method while retaining essentially the same interpretation of the phenomenon. A legal archive can be reinterpreted after a conceptual change without any new computation. A corpus can undergo both: new text-analysis tools can identify a pattern, and a new historical framework can alter what that pattern means. Preservation architecture should therefore support both analytical recomputation and contextual reconstruction when the expected future use warrants them.

Proposition 17.167 (Reanalysis–reinterpretation distinction). *Future reanalysis and future reinterpretation should be treated as distinct re-epistemization pathways because changes in analytical operation do not by themselves determine changes in meaning, while changes in meaning can occur without materially different analytical*

operations.

Future reinterpretation also depends strongly on preservation of plurality and context. If only the final institutional interpretation survives, later inquiry can struggle to reconstruct excluded voices or alternative meanings. If categories survive without their historical consequences, later analysts can underestimate how classification shaped action. If testimony survives without language, translation, or relational context, meaning can be flattened. Preservation therefore supports reinterpretation through connections among records rather than through isolated survival.

This temporal openness has limits. Later interpreters can overproject present categories, selectively mobilize fragments, or erase the constraints faced by earlier actors. Responsible reinterpretation should preserve the distinction between the later standpoint and the historical standpoint. Re-epistemization changes what later inquiry can responsibly claim about the past; it does not imply retroactive alteration of the underlying historical process.

17.13.8 Preservation Cost

Preservation is an economic activity with continuing costs. Storage and physical conservation are only the visible components. Long-horizon preservation can require metadata creation, format migration, integrity checks, cybersecurity, privacy review, legal compliance, cataloguing, software maintenance, access governance, documentation, translation, curatorial judgment, community consultation, and institutional succession. It also consumes attention. Simon's analysis of information-rich environments is relevant here: abundant information can shift scarcity toward the attention required to select and process it (Simon 1971). A repository that preserves enormous volume without adequate discoverability or curation can therefore accumulate records while weakening practical epistemic access.

Costs are distributed across positions and time. Record creators may externalize curation burdens onto repositories. Institutions can preserve material while transferring privacy or security risks to represented persons. Future users can inherit obsolete formats or undocumented dependencies. Small organizations and communities can face proportionally larger compliance and migration burdens than well-funded institutions. Preservation policy should therefore ask who pays, who carries risk, who retains access, and who gains future option value.

Definition 17.168 (Epistemic preservation cost profile). An *epistemic preservation cost profile* is the temporally distributed configuration of financial, material, computational, organizational, documentary, legal, ethical, security, and attention costs required to keep an epistemic preservation configuration usable for its intended future functions.

The cost profile includes opportunity cost. Resources committed to indefinite retention of easily regenerable or low-dependency material can reduce capacity to preserve unique archives, vulnerable records, minority-language materials, transient observations, or high-dependency datasets. Selection therefore occurs in practice even when institutions do not articulate a preservation policy. Unmanaged selection can arise through format decay, service closure, staff turnover, proprietary lock-in, funding discontinuity, and unequal visibility. Explicit selection can at least make the

governing criteria contestable.

One useful object of analysis is a preservation portfolio rather than an isolated record. Different records can justify different retention horizons, redundancy levels, access controls, documentation effort, and migration schedules. Some materials can be regenerated cheaply; others are unique. Some require open access to retain value; others require restricted custody. Some are valuable mainly as provenance for a high-stakes decision; others derive value from broad recombination. Portfolio design can therefore allocate resources according to irrecoverability, dependency, future reconstructive value, generative option value, risk, and continuing cost.

Proposition 17.169 (Preservation-portfolio condition). *Under finite preservation resources, an epistemic system can improve future re-epistemization capacity by differentiating preservation effort according to the irrecoverability, dependency structure, reconstructive value, generative option value, access obligations, risk profile, and continuing cost of the records concerned.*

Proposition 17.169 is a scoped design principle for heterogeneous preservation decisions. The dimensions are heterogeneous and can conflict. A unique record can carry severe privacy risk. A low-cost dataset can have little future value. A culturally significant archive can warrant stewardship for reasons that are poorly represented by expected commercial reuse. The appropriate portfolio therefore depends on institutional purpose, affected positions, ethical and legal obligations, and the uncertainty surrounding future uses.

Definition 17.170 (Re-epistemization capacity). *Re-epistemization capacity* is the practical ability of a later epistemic configuration to reconstruct, verify, reanalyze, reinterpret, reconnect, or contest earlier knowledge claims and records under changed evidential, methodological, conceptual, technological, institutional, or normative conditions.

Re-epistemization capacity provides the integrative concept for this section. Record preservation supplies trace; provenance supplies lineage; alternative interpretations preserve branching possibilities; negative results preserve unsuccessful but informative search; historical context preserves situated meaning; reanalysis reopens analytical operations; reinterpretation reopens significance; and preservation-cost analysis governs which of these capacities can be sustained. The resulting architecture treats epistemic memory as active infrastructure that can support future inquiry, verification, and reinterpretation.

This perspective also clarifies the relation between preservation and generativity. Preservation can conserve accumulated knowledge, but its more distinctive contribution lies in maintaining the possibility that future agents form new relations with inherited epistemic material. A preserved archive can become newly salient; an obsolete dataset can support a new comparison; a rejected interpretation can become relevant under changed evidence; a negative result can prevent repeated expenditure; and provenance can reconnect a contribution to persons or communities whose role was previously obscured. Preservation therefore helps transmit possibilities for future knowing, while selection, decay, enclosure, and loss alter those possibilities.

The section also establishes a boundary for the chapter's next movement. Preservation and re-epistemization explain how epistemic objects can remain available and

revisable across time. The next analytical object is the transformation of the knower through participation in knowledge practices. Section 17.14 therefore turns to knowing as relational participation, examining learning, transformation of the knower, human–object and human–human relations, human–AI learning relations, knowledge beyond immediate instrumental utility, subjective continuity, and the transformation of future possibility through knowing.

17.14 Knowing as Relational Participation

This section develops the participatory dimension of the epistemic economy. Sections 17.1–17.13 have analyzed knowledge as an economic object, the infrastructures and institutions that organize it, the asymmetries and justice questions that arise around it, and the conditions under which epistemic material remains available across time. The present section changes analytical level. Its objective is to examine how participation in knowing can transform the knower, relations with epistemic objects and other persons, and the range of later questions, interpretations, judgments, and actions that become feasible. The discussion proceeds through learning, transformation of the knower, human–object relations, human–human learning relations, human–AI learning relations, knowledge beyond immediate instrumental utility, subjective continuity through knowing, and transformation of future possibility. The method is relational and capability-oriented. Knowing is treated as a temporally extended participation process whose economic significance depends on changes in capacities and possibilities, with information transfer treated as one possible component.

This formulation is compatible with multiple psychologies of learning. Learning can occur through instruction, practice, imitation, experimentation, reading, dialogue, observation, error correction, participation in a community, interaction with tools, or repeated engagement with an object. Dewey’s account of reflective inquiry emphasizes the educational cultivation of inquiry and the movement through perplexity, observation, suggestion, and inference (Dewey 1910). Lave and Wenger develop situated learning through legitimate peripheral participation, locating learning within changing participation in communities of practice (Lave and Wenger 1991). Wenger later makes the relation among learning, practice, meaning, community, and identity explicit in a social theory of learning (Wenger 1998). These traditions differ in object and method, yet they support a shared caution against representing learning only as the transfer of a detachable stock into an otherwise unchanged individual.

Within GRE, the economic issue is therefore broader than acquisition. A learning process can change what a subject notices, which distinctions are intelligible, what evidence can be evaluated, which tools can be used, whose testimony can be assessed, what collaborations become possible, and which future questions can be formulated. These changes can affect employment and productivity, as human-capital approaches emphasize (Becker 1964), while also affecting capabilities whose significance appears through research, civic participation, cultural practice, personal orientation, or later unforeseen use. The present section retains these heterogeneous consequences and their potentially different measures.

Table 17.14: Dimensions of knowing as relational participation in the epistemic economy

Dimension	Relational transformation	Economic relevance
Learning	Change in later epistemic capability through participation	Alters feasible tasks, inquiry, verification, communication, and adaptation
Transformation of the knower	Reorganization of attention, habits, categories, confidence, standards, or identity relations	Changes later orientation, conversion capacity, and participation
Human–object relations	Repeated engagement with texts, instruments, data, environments, artifacts, or phenomena	Conditions perception, skill, interpretation, and object-specific competence
Human–human learning	Teaching, testimony, apprenticeship, mentoring, collaboration, disagreement, and peer practice	Distributes capability, authority, tacit practice, and access to communities
Human–AI learning	Interaction with generative, analytic, retrieval, feedback, or tutoring systems	Can complement, substitute for, or reorganize human epistemic capability
Knowledge beyond instrumental utility	Inquiry whose value is aesthetic, cultural, civic, existential, exploratory, or retrospectively recognized	Creates long-horizon option value and preserves plural orientations of inquiry
Subjective continuity	Connection of prior learning and commitments with present and future epistemic orientation	Supports accumulated capability, agency, memory, and long-horizon projects
Future possibility	Expansion, redirection, or closure of later questions, relations, practices, and actions	Makes knowing itself part of the generation of later economic possibility

Definition 17.171 (Relational epistemic participation). *Relational epistemic participation* is a temporally extended involvement in practices, objects, persons, tools, institutions, or computational systems through which a subject’s epistemic capacities, orientations, relations, or feasible future inquiries can be modified.

Definition 17.171 places transformation rather than mere contact at the center of the concept. Reading a text, attending a lecture, consulting a model, or interacting with an AI system can create an opportunity for learning without guaranteeing that learning occurs. The analytical question concerns what changes in the subject’s later epistemic capability and how that change depends on the relation in which participation occurred.

Table 17.14 summarizes the eight dimensions developed in this section.

17.14.1 Learning

Learning is economically consequential when participation changes what a subject can subsequently do epistemically. This change can involve recall, conceptual discrimination, procedural skill, model use, interpretation, verification, explanation, translation, communication, question formation, or the ability to enter a more demanding practice. The relevant change can be narrow and task-specific or broad and reorganizing. It can also decay when practice stops, institutions disappear, tools become unavailable, or the learned capacity depended heavily on a context that is no longer present.

A capability-based definition helps distinguish learning from exposure. A learner can receive the same information repeatedly without acquiring the ability to use it. Conversely, a person can acquire a durable practical capacity through participation even when the resulting knowledge is difficult to state propositionally. Lave and Wenger's account of legitimate peripheral participation is especially useful here because it treats access to practice, relations with established participants, use of artifacts, and changing participation as constitutive conditions of learning within social practice (Lave and Wenger 1991). This perspective is compatible with GRE's interest in the economic organization of learning opportunity: who can enter the relevant practice, remain long enough to develop competence, gain access to its tools and language, and receive recognition as participation changes.

Definition 17.172 (Epistemic learning change). An *epistemic learning change* is a sufficiently persistent modification of a subject's capacity to perceive, distinguish, understand, inquire, verify, communicate, or act with respect to a specified epistemic domain after participation in a learning relation.

Persistence in Definition 17.172 is purpose-relative. A short-lived correction can matter in a one-time task; professional competence requires more durable capability; language acquisition, research judgment, or craft skill can require repeated participation over long periods. The temporal threshold is therefore purpose-relative across learning domains.

Human-capital analysis captures one important economic pathway: education and training can increase productive capability and affect earnings and employment (Becker 1964). GRE retains that pathway while distinguishing it from the full epistemic effect of learning. A course can increase employability, enable participation in a scientific field, change the questions a learner recognizes as meaningful, expand access to a linguistic community, and alter confidence in dealing with institutions. These outcomes can overlap without becoming reducible to a single productivity increment.

Proposition 17.173 (Learning-capability condition). *Participation counts as economically consequential learning within the epistemic economy when it produces a sufficiently persistent change in later epistemic capability that alters feasible participation, inquiry, verification, communication, production, or adaptation in the domain under analysis.*

Proposition 17.173 also clarifies evaluation. Immediate task success is evidence about performance under the conditions of the task. It is incomplete evidence about learning when assistance, prompts, external memory, collaborators, or computa-

tional systems carry part of the capability. Evaluation should therefore distinguish assisted performance from changes that remain available to the subject across later situations.

17.14.2 Transformation of the Knower

Learning can modify the knower more broadly than a discrete skill or proposition. Repeated participation can reorganize habits of attention, categories of interpretation, standards of evidence, confidence in particular practices, relations of trust, expectations about what questions are legitimate, and the identities through which a person locates themselves in an epistemic field. Such transformations can be gradual and partly reversible. They can also be heterogeneous: a subject may become more capable in one domain while becoming more dependent on a particular institution, language, interface, or community.

Dewey's treatment of habit provides one precedent for understanding learned dispositions as relations between organism and environment rather than as isolated internal possessions (Dewey 1922). Mead's social account of the self likewise emphasizes that self-formation occurs through socially organized interaction and role-taking (Mead 1934). Wenger's theory of communities of practice connects learning with identity formation through changing participation in shared practice (Wenger 1998). GRE retains the theoretical distinctness of these traditions. Their relevance lies in showing different mechanisms through which knowing can alter the subject's later relations to practices, persons, and possibilities.

Definition 17.174 (Knower-transformation profile). *A knower-transformation profile describes the changes in epistemic capacity, attention, interpretive categories, habits, confidence, standards, relational position, and identity-relevant orientation associated with a specified history of knowing.*

This profile prevents the language of transformation from becoming totalizing. Learning a statistical method may leave the learner's broader identity largely unchanged. Becoming a physician, historian, engineer, archivist, lawyer, craft worker, or member of a research community can nevertheless involve transformations that extend beyond task competence because the practice changes what counts as relevant evidence, acceptable explanation, responsible judgment, or recognizable participation. The empirical scope of the transformation should be established rather than assumed from the importance of the practice.

Transformation also has economic path dependence. A prior learning history can reduce the cost of entering some later practices while raising the cost of changing orientation. Specialized vocabulary can make a field intelligible while making communication across fields more demanding. Professional formation can create access to institutions and networks while binding recognition to credentials or norms. The resulting path dependence is neither inherently beneficial nor inherently restrictive. Its evaluation depends on later capabilities, alternatives, dependencies, and the values at stake.

Proposition 17.175 (Epistemic path-formation condition). *A history of knowing becomes path-forming when the capacities, habits, categories, relations, or recognitions generated through earlier participation materially alter the cost, intelligibility, feasibil-*

ity, or attractiveness of later epistemic pathways.

Proposition 17.175 makes learning history part of economic history. Educational access, mentorship, professional formation, language learning, platform dependence, and disciplinary specialization can influence later opportunity because they change the subject that encounters later choices.

17.14.3 Human–Object Relations

Knowing commonly develops through repeated relations with objects of inquiry. The relevant object can be a text, dataset, instrument, archive, proof, machine, organism, landscape, artwork, legal record, chemical material, software system, historical trace, or other phenomenon. The term *object* names the pole of an epistemic relation while leaving open whether the object is a commodity, material artifact, living system, representation, or another analytically relevant configuration. Ontological suspension remains in force. The analytical concern is how a subject’s capacities change through situated engagement with something that resists, affords, surprises, constrains, or supports particular forms of inquiry.

Phenomenological and ecological traditions supply useful precedents for this relational emphasis. Merleau-Ponty treats perception as embodied and situated rather than as the accumulation of detached sensations (Merleau-Ponty 2012). Gibson’s ecological approach analyzes affordances through organism–environment complementarity, making possible actions relational to both environmental properties and the capabilities of the perceiver (Gibson 1979). GRE uses these traditions cautiously. They show why epistemic competence can depend on cultivated relations with an object or environment, without establishing one universal theory of perception or knowledge.

Definition 17.176 (Epistemic object relation). An *epistemic object relation* is a situated and temporally extended relation in which engagement with an object, phenomenon, representation, or environment modifies a subject’s capacity to perceive, interpret, manipulate, verify, explain, or inquire concerning that object or related objects.

Object-specific competence often depends on repeated encounter. A clinician learns to distinguish patterns that a novice may not notice. An archivist learns how material form, provenance, and cataloguing history affect interpretation. A programmer learns a codebase partly through its failures and dependencies. A naturalist develops perceptual discriminations through sustained contact with organisms and environments. In each case, access to the object, time for repeated engagement, suitable tools, feedback, and opportunities to compare cases contribute to the learning relation.

The economic organization of objects therefore matters. Paywalls, proprietary instruments, restricted archives, scarce laboratory time, geographic distance, safety rules, linguistic barriers, interface design, or ownership of technical systems can condition which epistemic object relations can form. Open access can widen encounter while leaving expertise or equipment scarce. Formal access can coexist with weak learning when a user cannot manipulate, compare, revisit, or contextualize the object. Section 17.11 analyzed these issues as infrastructure; the present subsection emphasizes their effects on the formation of knower–object relations.

Proposition 17.177 (Object-relation learning condition). *Where competence depends on repeated, feedback-bearing engagement with an epistemic object, access to representations alone provides an incomplete substitute for the object relation unless the representation preserves the relevant opportunities for discrimination, manipulation, comparison, or response.*

This condition is domain-specific. A high-quality digital reproduction can preserve much of what one inquiry requires and very little of what another requires. The relevant question is which relation carries the epistemic work in the specified practice.

17.14.4 Human–Human Learning Relations

Human learning is frequently mediated by other persons. Teaching, testimony, apprenticeship, mentoring, collaboration, peer review, demonstration, disagreement, imitation, correction, and shared problem solving distribute epistemic capacity through relations that differ in authority and reciprocity. These relations can transmit explicit knowledge, practical judgment, tacit routines, norms of evidence, professional language, and access to communities whose resources are difficult to obtain individually.

Lave and Wenger’s analysis is again useful because it relocates apprenticeship from a simple dyad between master and novice to a wider structure of participation, artifacts, established participants, and changing identity (Lave and Wenger 1991). Wenger’s later account similarly treats learning as participation in practices through which meaning and identity are jointly organized (Wenger 1998). This perspective fits the epistemic economy because the capacity to learn depends partly on membership, legitimacy, time, access to experienced participants, visibility of practice, and the distribution of opportunities to undertake increasingly consequential work.

Definition 17.178 (Human learning relation). *A human learning relation is an interpersonal or collective relation in which testimony, demonstration, dialogue, correction, collaboration, evaluation, or shared practice contributes to a change in one or more participants’ epistemic capabilities or orientations.*

Asymmetry can be productive within such relations. A teacher can know more than a student about the subject being taught; a supervisor can possess greater institutional experience; a craft worker can possess practical judgment unavailable to a newcomer. Section 17.7 established that epistemic asymmetry and power should remain analytically distinct, while Section 17.12 established that asymmetry and injustice are non-equivalent. The present implication is that learning relations should be evaluated through their mechanisms: whether authority supports capability formation, whether participants can question and contest, whether dependence diminishes as competence grows, and whether recognition and access are distributed in defensible ways.

Human–human learning can also be reciprocal without being symmetrical. A researcher may contribute formal methods while a community participant contributes contextual knowledge. Interdisciplinary collaborators may possess different forms of expertise. A mentor can learn from a novice’s questions because unfamiliar questions reveal assumptions that established practice no longer notices. Reciprocity therefore concerns the possibility of consequential contribution and transformation across po-

sitions even when prior knowledge differs across domains.

Proposition 17.179 (Relational learning complementarity). *Human learning relations can generate epistemic capacity through complementarity when differentiated knowledge, experience, perspective, or practice becomes mutually accessible through interaction without requiring identical competence across participants.*

The economic conditions of such complementarity include time, trust, language, institutional protection, recognition, manageable hierarchy, and repeated interaction. Short contracts, extreme workload, exclusionary credential structures, or highly competitive evaluation can weaken knowledge transmission even when knowledgeable persons occupy the same organization.

17.14.5 Human–AI Learning Relations

Artificial intelligence adds a distinctive learning relation because a computational system can participate in search, explanation, example generation, feedback, translation, simulation, coding, drafting, diagnosis, and problem decomposition at low marginal response cost. The relation can be interactive and adaptive at the level of the user’s session, while human social participation remains analytically distinct. GRE therefore treats human–AI learning as a mediated epistemic relation and remains agnostic about machine personhood or subjective experience.

AI assistance can alter learning through several mechanisms. It can reduce the cost of receiving explanations, generate additional practice material, translate across languages or representations, expose a learner to alternative approaches, provide rapid feedback, and make specialized symbolic work accessible to persons with less prior experience. Workplace evidence on generative AI is consistent with some forms of capability diffusion: Brynjolfsson, Li, and Raymond report larger productivity gains among less experienced and lower-skilled customer-support workers and evidence consistent with diffusion of more effective practices (Brynjolfsson et al. 2025). The empirical result concerns a particular work setting and supports only a setting-bounded inference about learning and knowledge diffusion.

The central analytical distinction is between *assisted performance* and *human learning*. An AI system can raise current performance because part of the relevant capability remains external to the user. Learning is stronger when the relation changes what the person can later perceive, explain, verify, generate, or do across relevant situations. The two can coincide. They can also diverge.

Definition 17.180 (Human–AI epistemic learning relation). *A human–AI epistemic learning relation is a recurrent interaction in which an AI system supplies generation, retrieval, transformation, feedback, simulation, or evaluative support and in which the relevant analytical question is how that interaction changes the human participant’s later epistemic capabilities, dependencies, orientations, or feasible actions.*

Proposition 17.181 (Assisted-performance–learning distinction). *An improvement in task performance under AI assistance provides incomplete evidence of human learning unless the analysis also establishes a relevant change in the human participant’s later epistemic capability, including where appropriate performance with reduced or differently structured assistance.*

Proposition 17.181 has implications for education and work design. If an AI system performs the diagnostic, interpretive, or generative operations that a learner is expected to acquire, repeated successful completion can coexist with weak capability formation. Conversely, carefully structured use can expose reasoning, provide varied practice, support metacognitive comparison, and free attention for higher-level judgment. The outcome depends on task design, feedback, learner activity, verification requirements, prior knowledge, interface design, and the distribution of responsibility between human and system.

Human–AI learning can also generate new dependencies. A learner may become able to undertake more complex projects only while a particular model, platform, or interface remains available. Such dependence can be productive when it functions like dependence on other legitimate infrastructure, including libraries, calculators, statistical software, or laboratory instruments. It becomes analytically concerning when capability, verification, autonomy, or exit options become fragile under concentrated control, opacity, or discontinuity. Chapter 18 will treat these asymmetries at greater depth.

17.14.6 Knowledge beyond Instrumental Utility

The economic organization of knowing also includes inquiry whose significance is weakly represented by immediate instrumental output. People learn languages, history, mathematics, philosophy, music, natural history, craft, religious traditions, literature, and scientific subjects for combinations of practical, cultural, aesthetic, civic, intellectual, relational, and existential reasons. Some of these activities later produce measurable economic returns. Others contribute to judgment, identity, participation, curiosity, cultural continuity, or the capacity to recognize possibilities that were not specified in advance.

Dewey's aesthetics is relevant because it treats aesthetic experience as a temporally organized interaction between a living subject and an environment, preserving a domain of value that exceeds a solely external-utility representation (Dewey 1934). Sen's capability approach likewise directs attention toward substantive opportunities and forms of being and doing alongside resources and income (Sen 1999). GRE draws a narrower conclusion: epistemic-economic analysis can investigate the conditions that support heterogeneous forms of knowing while leaving their value plural and only partly represented by immediate productivity or monetary return.

Definition 17.182 (Open-horizon epistemic value). *Open-horizon epistemic value* is the value associated with knowing whose later significance remains partly unspecified at the time of learning and may emerge through future inquiry, judgment, relation, cultural participation, personal orientation, or unforeseen recombination.

Open-horizon value differs from a claim that every inquiry will eventually become useful. Many inquiries produce little later consequence; some consume resources that could have supported more urgent purposes. The concept identifies uncertainty about future significance rather than guaranteeing future payoff. It is therefore compatible with economic questions about opportunity cost, portfolio design, institutional mission, and plural values.

Long-horizon inquiry is especially exposed to evaluation systems that demand

early specification of output. Section 17.5 showed that questions can require protected time before their significance becomes clear, while Section 17.6 analyzed aesthetic and epistemic orientation under incomplete criteria. The present argument adds the knower: exploratory learning can change the subject who later recognizes a problem. A future application may become visible only because earlier non-instrumental learning created the categories, sensitivities, or relations through which the later situation becomes intelligible.

Proposition 17.183 (Delayed recognizability of epistemic value). *The economic value of a learning process can remain partly unrecognizable at the time of participation when its later consequence depends on future questions, relations, institutions, technologies, or transformations of the knower that have not yet been specified.*

This proposition supports neither unlimited funding nor a hierarchy in which non-instrumental inquiry is superior to applied work. It identifies one reason why evaluation based exclusively on near-term output can systematically undervalue some epistemic trajectories.

17.14.7 Subjective Continuity through Knowing

Knowing can also participate in the temporal continuity through which a subject relates prior experience, present orientation, and future projects. A person can remember what they once learned, revise an earlier belief, recognize how a professional practice changed their standards, reconnect with a language or tradition, or integrate knowledge acquired in one domain into a later role. These processes give accumulated learning a biographical structure. They also make epistemic loss potentially more than loss of usable information when the lost practice, language, archive, or community helped organize the subject's relation to their own history.

The analysis requires ontological restraint. GRE brackets the metaphysical conditions of personal identity. Archer's account of human agency distinguishes selfhood, personal identity, social identity, and role occupancy and provides one social-theoretical precedent for treating personal continuity as related to, yet not exhausted by, social roles (Archer 2000). Mead's social theory of the self provides another mechanism through which socially organized interaction participates in self-formation (Mead 1934). The present argument is narrower: epistemic histories can become resources through which subjects maintain, revise, or reconnect their orientations across time.

Definition 17.184 (Subjective epistemic continuity). *Subjective epistemic continuity is the practical capacity of a subject to connect prior learning, experiences, commitments, and interpretive resources with present understanding and future epistemic projects while allowing revision of those earlier states.*

Continuity therefore differs from rigidity. A scientist can preserve continuity with earlier research while rejecting an old model. A migrant can maintain a language while acquiring another. A professional can reinterpret prior training after entering a different institution. Revision can strengthen continuity when it enables a subject to understand how earlier and later positions are related.

The economic conditions of continuity include time, access to records and com-

munities, linguistic opportunity, educational pathways, institutional memory, portability of credentials, and the ability to re-enter practices after interruption. Forced displacement, exclusion from professional communities, loss of archives, prolonged deskilling, language suppression, or abrupt technological change can weaken continuity by severing relations through which earlier capacities remain usable or intelligible. These mechanisms should be studied empirically rather than inferred from disruption alone.

Proposition 17.185 (Epistemic continuity condition). *Subjective epistemic continuity is strengthened when prior learning remains practically reconnectable to present interpretation and future projects through usable memory, records, language, relations, practices, or institutions, while preserving the subject's capacity to revise earlier understanding.*

This condition links the present section to Section 17.13. Preservation concerns continuity of epistemic traces across time; subjective continuity concerns the subject's capacity to form a living relation with inherited or remembered epistemic material. One can exist without the other. An archive can survive without being integrated into anyone's present practice, while a subject can preserve practical knowledge through embodied or social continuity even where formal records are sparse.

17.14.8 Knowing as Transformation of Future Possibility

The preceding dimensions converge on a generative claim. Knowing can transform future possibility because learning changes the subject who encounters later situations. A new capacity can make a previously inaccessible object manipulable, a new language can open a community and archive, a new concept can make a pattern recognizable, a new relation can provide entry to a practice, and a revised standard of evidence can alter which claims become credible. These transformations can expand possibilities, redirect them, or close some pathways as specialization, dependency, commitment, or institutional recognition develops.

The generative effect should therefore be stated conditionally. Knowledge can expand, redirect, or contract later freedom and social value depending on its mechanisms and consequences. Expertise can entrench narrow categories; institutional learning can reproduce exclusion; training can bind a worker to proprietary infrastructure; persuasive falsehoods can also transform later behavior. Generativity describes a change in subsequent possibility, while normative evaluation asks which transformations should be supported, constrained, repaired, or contested.

Definition 17.186 (Epistemic generative transformation). *An epistemic generative transformation is a change produced through knowing that materially alters the subject's or group's later feasible questions, interpretations, relations, practices, decisions, or capacities for further learning.*

The definition places learning inside the wider GR vocabulary of generated possibility without treating knowledge as a homogeneous causal substance. The transformation can arise through explicit instruction, repeated practice, participation in a community, encounter with an object, preservation of a trace, dialogue with another person, or human–AI interaction. Its mechanism should be identified at the level relevant to the case.

Proposition 17.187 (Future-possibility condition). *Knowing becomes generatively consequential within GRE when the change in epistemic participation can be linked to a later change in the feasible set, accessibility, cost, intelligibility, or orientation of subsequent epistemic or economic possibilities.*

Proposition 17.187 provides a bridge between the epistemic economy and the book's broader substantive architecture. Educational investment can matter because it changes later capability. Research participation can matter because it changes what questions a community can pursue. Language learning can matter because it changes accessible relations and records. Human–AI interaction can matter because it changes the division of epistemic labor and the user's later capacities or dependencies. Cultural and exploratory learning can matter because it preserves orientations and possibilities whose later use was not predetermined.

The distribution of these transformations is an economic and political question. Subjects differ in time, security, prior education, language, access to objects, mentorship, institutional recognition, computational support, and opportunities for sustained practice. A society can therefore distribute formal information widely while distributing the capacity to become a transformed knower very unevenly. Section 17.12 identified the justice dimensions of such arrangements; the present section identifies the participatory mechanism through which unequal epistemic conditions can become unequal future capability.

Knowing as relational participation also clarifies the chapter's movement toward knowledge commons. If learning depends partly on access to practices, objects, languages, repositories, infrastructures, and other participants, then the governance of shared epistemic resources affects more than information distribution. It affects who can enter learning relations, who can contribute to them, whose contributions remain attributable, whether shared infrastructures persist, and whether participation reproduces or expands generative capacity. Section 17.15 therefore turns to knowledge commons and open epistemic systems as institutional arrangements for governing these shared conditions of knowing.

17.15 Knowledge Commons and Open Epistemic Systems

This section develops the commons dimension of the epistemic economy. Section 17.14 treated knowing as relational participation and showed that learning depends partly on access to practices, objects, people, repositories, languages, infrastructures, and computational systems. The present section asks how some of these shared conditions can be organized so that knowledge remains accessible, contributable, revisable, attributable, and maintainable across heterogeneous participants and over time. Its objective is to distinguish open access from shared infrastructure, commons governance, attribution, reciprocity, sustainability, protection against generative exploitation, and plural knowledge systems. The discussion proceeds through these eight dimensions. The method is institutional and relational: openness is analyzed through concrete access conditions, governance relations, maintenance burdens, contribution pathways, and downstream conversions rather than treated as an undifferentiated property of information.

Knowledge commons have an established institutional literature. Hess and Ostrom extend commons analysis to knowledge and emphasize that access, enclosure, intellectual property, preservation, technological change, and collective governance can be studied without assuming that knowledge behaves exactly like a natural-resource common pool (Hess and Ostrom 2007). Benkler's analysis of commons-based peer production shows that distributed contributors can coordinate productive activity through arrangements that differ from both conventional market exchange and managerial hierarchy (Benkler 2002). Frischmann, from an infrastructure perspective, emphasizes the social value of shared resources whose downstream uses are heterogeneous and partly unpredictable (Frischmann 2012). UNESCO's Recommendation on Open Science similarly treats openness as a wider institutional architecture involving accessible knowledge, infrastructures, collaboration, participation, and respect for diverse knowledge systems rather than as a publication rule alone (UNESCO 2021).

GRE uses these resources while preserving several distinctions developed earlier in the chapter. Open access can expand availability without creating practical capability. Shared infrastructure can widen participation while remaining dependent on concentrated control. Attribution can protect provenance while leaving economic return unresolved. Reciprocity can support reproduction without requiring symmetrical exchange in every transaction. Sustainability concerns the reproduction of the commons itself and therefore includes maintenance labor, financing, preservation, governance, and succession. Finally, openness can coexist with generative exploitation when actors with stronger conversion capacity appropriate shared contributions in ways that weaken the conditions of continued generation. A knowledge commons is consequently analyzed here as a governed generative arrangement rather than as knowledge with restrictions removed.

Definition 17.188 (Knowledge commons). A *knowledge commons* is a governed relational configuration in which specified epistemic resources, practices, infrastructures, or capabilities are shared among a constituency through arrangements that organize access, contribution, use, attribution, maintenance, revision, and contestation across time.

Definition 17.188 is intentionally broader than a repository and narrower than knowledge in general. The shared object can include data, texts, software, models, standards, archives, educational materials, research instruments, linguistic resources, verification procedures, community practices, or combinations of these. The relevant constituency can be public, professional, local, disciplinary, organizational, or transnational. Different commons can therefore adopt different access and governance rules while remaining comparable through the functions those rules perform.

Table 17.15 summarizes the eight dimensions developed in this section.

17.15.1 Open Access

Open access concerns the conditions under which epistemic material can be discovered, reached, understood, and used by a relevant position. The term often refers to scholarly publications, yet the economic object is wider. Access can concern arti-

Table 17.15: Dimensions of knowledge commons and open epistemic systems

Dimension	Principal governance object	Generative relevance
Open access	Effective conditions of discovery, retrieval, intelligibility, and permitted use	Expands the positions from which epistemic participation can begin
Shared infrastructure	Repositories, networks, standards, software, compute, preservation, and verification facilities	Supplies reusable inputs for heterogeneous downstream inquiry and learning
Commons governance	Rules for membership, access, contribution, modification, decision, monitoring, and dispute	Coordinates shared use while preserving maintenance and revisability
Attribution	Provenance, credit, responsibility, and contribution lineage	Connects reuse to contributors and preserves reconstructible generative histories
Reciprocity	Direct, indirect, generalized, or structural forms of return	Helps reproduce contributor capability and shared conditions of generation
Sustainability	Maintenance labor, finance, preservation, succession, moderation, and security	Determines whether openness can persist beyond an initial release or contribution wave
Openness and exploitation	Conversion of open contributions under asymmetric capability or control	Identifies when openness supports broad generation and when it can facilitate one-sided appropriation
Plural knowledge systems	Relations among heterogeneous languages, practices, evidential traditions, institutions, and communities	Preserves multiple sources of inquiry while enabling bounded translation and contestation

cles, books, datasets, code, models, standards, educational materials, archives, instruments, metadata, public records, languages, or participation in a practice. A resource can be legally available while remaining practically inaccessible because it is difficult to discover, costly to retrieve, technically unusable, linguistically opaque, inaccessible to assistive technologies, or dependent on unavailable complementary infrastructure. Section 17.2 developed these access bottlenecks as forms of epistemic scarcity. The present subsection asks how openness changes them.

UNESCO's open-science framework is useful because it treats access to scientific knowledge together with infrastructures, engagement, collaboration, and diversity of knowledge systems (UNESCO 2021). The FAIR principles make a related infrastructural point for research data: findability, accessibility, interoperability, and reusability depend on metadata, persistent identification, protocols, licensing, and community standards rather than on nominal release alone (Wilkinson et al. 2016). GRE therefore treats openness as a profile with several components whose practical effects can diverge.

Definition 17.189 (Epistemic openness profile). An *epistemic openness profile* is the

configuration of legal, financial, technical, linguistic, discoverability, interoperability, accessibility, and reuse conditions that shape whether a specified constituency can practically reach and employ an epistemic resource or infrastructure.

This profile allows degrees and differentiated arrangements. A publication can be free to read while its underlying data remain controlled. A dataset can be downloadable while its documentation makes meaningful reuse difficult. An archive can provide public catalogues while restricting sensitive records through supervised access. A community can share knowledge internally while limiting external reuse because disclosure would create legal, cultural, ecological, or security risks. These arrangements differ in openness without requiring a single scalar ranking.

Open access also has an intertemporal dimension. Access at one moment can disappear when a platform closes, a file format becomes unreadable, a license changes, a repository loses funding, or links decay. Durable openness therefore depends partly on the preservation architecture developed in Section 17.13. Access that cannot survive foreseeable infrastructural change provides a weaker basis for cumulative inquiry than access supported by preservation, provenance, portability, and institutional continuity.

Proposition 17.190 (Effective openness condition). *An epistemic resource is effectively open for a specified constituency only to the extent that the relevant members can discover, access, interpret, and use it under the technical, linguistic, institutional, and legal conditions material to the intended epistemic function.*

Proposition 17.190 does not require unrestricted access. Privacy, confidentiality, safety, stewardship obligations, contractual commitments, community governance, and risks of harmful reuse can justify differentiated access. The analytical requirement is to identify which constituency, which function, and which restrictions are being evaluated. Openness becomes economically meaningful through the practical capabilities it creates or withholds.

17.15.2 Shared Infrastructure

Knowledge commons depend on infrastructures that can be used by multiple participants across multiple downstream purposes. Repositories, archives, networks, persistent identifiers, open standards, shared software, reference corpora, public databases, translation systems, compute facilities, verification services, and educational resources can all function as epistemic infrastructure when they support recurrent activity beyond a single transaction. Frischmann's infrastructure analysis is relevant because shared infrastructural resources can generate substantial social value precisely when downstream uses are heterogeneous and cannot be fully specified in advance (Frischmann 2012).

The economic significance of shared infrastructure lies partly in option creation. A well-maintained repository can support questions that its creators did not anticipate. An interoperable standard can permit coordination among organizations that were not originally connected. Publicly accessible software can allow small research groups to perform analyses that would otherwise require proprietary systems. A multilingual terminology resource can connect communities that previously lacked a usable translation interface. These effects need empirical demonstration in particular

cases, yet the general mechanism is consistent with the chapter's account of generative infrastructure: shared inputs can alter later feasible sets.

Definition 17.191 (Shared epistemic infrastructure). *Shared epistemic infrastructure* is an infrastructural resource or coordinated set of resources whose recurrent use by multiple participants supports the generation, interpretation, verification, preservation, communication, or reuse of knowledge across more than one immediate activity.

Shared infrastructure differs from simply common ownership. A privately owned indexing service can function as widely shared infrastructure; a publicly owned repository can be difficult for relevant users to access; a community-maintained software project can be shared while relying on privately controlled hosting. Ownership, control, access, maintenance, and infrastructural function should therefore be represented separately, consistent with Sections 17.8 and 17.11.

Infrastructure sharing also creates dependencies. Participants can become reliant on a standard, repository, software library, compute service, or identity system whose governance they do not control. A change in terms of use, technical architecture, pricing, or access policy can then propagate across many downstream practices. Shared infrastructure consequently creates both economies of reuse and possible concentration of infrastructural power. Commons governance becomes relevant because the question is not simply whether many people can use an infrastructure, but how its rules, maintenance, revision, and exit conditions are organized.

Proposition 17.192 (Shared-infrastructure generativity condition). *Shared epistemic infrastructure becomes generatively consequential when recurrent access to the infrastructure materially changes the cost, accessibility, interoperability, or feasible range of downstream epistemic activities for multiple participants.*

The condition in Proposition 17.192 remains complement-dependent. Open software has limited effect without usable hardware and skills. A public dataset has limited effect without metadata, verification, or interpretive capacity. Shared compute has limited scientific value when data access or methodological competence is absent. Infrastructure should therefore be evaluated as a connected configuration rather than through the availability of one component alone.

17.15.3 Commons Governance

Commons governance organizes the relations through which shared epistemic resources are accessed, contributed to, modified, maintained, and contested. The commons literature is useful here because it directs attention away from a simple market-state opposition and toward institutional diversity, rules in use, monitoring, collective choice, and polycentric arrangements (Ostrom 2010; Hess and Ostrom 2007). Knowledge commons differ from many natural-resource commons because use of information is often less directly subtractive. Yet congestion, attention burdens, verification costs, maintenance labor, privacy risks, contributor exhaustion, infrastructure capacity, and appropriation of shared outputs can still create collective-action problems.

Governance can operate at several layers. Entry rules determine who can read,

contribute, modify, review, or administer. Contribution rules determine acceptable formats, evidence, provenance, licensing, or community standards. Decision rules determine how categories, interfaces, priorities, and policies change. Monitoring and moderation rules respond to vandalism, low-quality contribution, abuse, or security problems. Conflict procedures organize appeals and disagreements. Maintenance rules allocate routine work that may be less visible than high-status contribution. Federation rules determine how one commons connects to others.

Definition 17.193 (Knowledge-commons governance). *Knowledge-commons governance* is the arrangement of decision rights, access rules, contribution procedures, maintenance responsibilities, monitoring practices, conflict-resolution pathways, and revision mechanisms through which a shared epistemic configuration is reproduced and changed.

The definition permits both formal and informal governance. An open-source project can have maintainers, contribution protocols, review norms, release processes, and informal authority even when it is not governed through a conventional corporation. A local knowledge archive can operate through community stewardship and permission practices. A research consortium can use formal contracts and shared committees. A public repository can combine statutory mandates with technical rules embedded in software. Governance is therefore distributed across legal, institutional, technical, and relational layers.

A generative perspective also asks whether governance preserves the commons' capacity to receive new participants and adapt to changing conditions. Rules that stabilize quality can become barriers when they assume resources, credentials, languages, or technologies unavailable to potential contributors. Conversely, extremely low contribution thresholds can overwhelm review and maintenance capacity. Governance adequacy therefore depends on the relation among the object, constituency, risks, contribution structure, maintenance burden, and desired degree of openness.

Proposition 17.194 (Commons-governance fit condition). *The adequacy of a knowledge-commons governance arrangement depends on how its access, contribution, decision, maintenance, monitoring, and revision rules fit the characteristics of the shared epistemic objects, the participating constituency, the material risks, and the temporal requirements of continued generation.*

Proposition 17.194 resists a universal institutional template. A biomedical data commons, a mathematical software project, a public library, a language archive, and a community-governed ecological knowledge repository can require materially different access and stewardship arrangements. Comparison remains possible at the level of governance functions without presuming identical rules.

17.15.4 Attribution

Openness increases the importance of attribution because reuse can separate an epistemic contribution from the social and historical setting in which it was generated. Attribution connects a claim, dataset, method, software component, translation, interpretation, or other contribution to its relevant sources and contributors. It can support credit, responsibility, provenance, auditability, and later reconstruction. Section 17.13 treated provenance as a preservation relation; the present subsection em-

phasizes the distributive and governance role of attribution inside open systems.

Attribution is multidimensional. Authorship credits intellectual contribution under disciplinary conventions. Citation links later claims to earlier sources. Version histories record modification. Data provenance tracks collection, transformation, and stewardship. Contributor records can recognize software maintenance, translation, moderation, documentation, curation, community liaison, or negative-result reporting that conventional authorship systems may underrepresent. Responsibility attribution can also identify who approved, reviewed, transformed, or released material. These functions overlap but should not be collapsed.

Definition 17.195 (Epistemic attribution architecture). An *epistemic attribution architecture* is the set of practices and records through which contributions, transformations, responsibilities, and source relations remain identifiable across the production, reuse, revision, and circulation of epistemic material.

Attribution does not imply exclusive ownership. Material can remain openly reusable while preserving contributor lineage. Attribution also does not settle compensation or authority. A named contributor can still receive little material return, and a heavily cited source can remain excluded from downstream governance. Conversely, anonymity or collective attribution can be appropriate where privacy, safety, community norms, or the character of collective production makes individual naming undesirable. The relevant principle is preservation of the form of recognition and responsibility appropriate to the epistemic relation.

Attribution is especially important where generative contributions are easy to aggregate and difficult to reconstruct after aggregation. Training corpora, large databases, collaborative software, encyclopedic platforms, and derivative datasets can contain many layers of prior contribution. Once provenance disappears, later participants may be unable to distinguish original observation from transformation, identify affected communities, evaluate quality, locate errors, or direct return. Attribution architecture therefore participates in both epistemic quality and relational justice.

Proposition 17.196 (Attribution–reuse condition). *Open reuse remains more compatible with contributor recognition and epistemic reconstructibility when the attribution architecture preserves the contribution and transformation relations material to credit, responsibility, provenance, and later evaluation.*

The proposition is intentionally scoped. Complete lineage can be technically costly or ethically inappropriate. An attribution architecture should therefore preserve the relations material to the purpose of the commons while respecting privacy, safety, collective authorship, and legitimate restrictions on disclosure.

17.15.5 Reciprocity

Knowledge commons frequently depend on contribution without immediate bilateral exchange. A researcher deposits data that later benefit unknown users. A software maintainer fixes a library used by organizations that never communicate with the maintainer. A translator makes an archive accessible to a future audience. A community contributes local observations to a shared monitoring system. Reciprocity in

such systems therefore cannot be represented only as direct repayment between two parties.

Theories of gift exchange show that reciprocity can be embedded in social obligations and durable relations rather than confined to spot exchange (Mauss 1990). Commons-based peer production likewise demonstrates that participants can contribute for heterogeneous reasons, including use value, reputation, learning, enjoyment, community membership, public benefit, and the improvement of a resource they themselves depend on (Benkler 2002). GRE treats these motivations as empirically variable and concentrates on the relational question of how returns circulate and whether the generative conditions of contributors and the commons are reproduced.

Definition 17.197 (Commons reciprocity). *Commons reciprocity* is the organization of direct, indirect, generalized, or structural returns through which contributors, users, stewards, or affected communities receive benefits, capabilities, recognition, access, governance standing, maintenance, or other value forms relevant to continued participation in a shared epistemic configuration.

Direct reciprocity can involve a contributor receiving a specific return from a user. Indirect reciprocity can occur when contributions are repaid through other members of the network. Generalized reciprocity can operate through expectations that participants contribute when able to a common resource from which many benefit. Structural reciprocity concerns the design of the system itself: open downstream improvements, contributor governance rights, shared infrastructure, capacity building, community benefit, or maintenance funding can return value without matching each contribution to a corresponding payment.

Reciprocity should remain distinct from equality of exchange. Knowledge contributions differ in effort, scarcity, risk, visibility, and social significance. Some contributors prefer public benefit to individualized return; others depend materially on compensation. A commons can therefore support heterogeneous return relations. The relevant question is whether the arrangement systematically relies on one group's generativity while directing recognition, control, or material benefit elsewhere in ways that undermine continued participation. Section 17.9 provides the stronger exploitation test for such cases.

Proposition 17.198 (Reciprocity–payment non-equivalence). *Reciprocity in a knowledge commons can be sustained through multiple value forms, so monetary payment is neither a necessary nor a sufficient indicator of whether contributors receive returns adequate to the continued reproduction of the relevant generative relations.*

The proposition leaves compensation questions open to the context. Some labor requires wages or fees for sustainable participation. Some commons depend on volunteer contribution that remains viable because participants receive use value, learning, status, community, or reciprocal maintenance. Evaluation should therefore identify which return forms matter to the contributors and which burdens are being externalized.

17.15.6 Sustainability

An epistemic resource can be openly released while the system that makes it usable deteriorates. Repositories require storage, migration, metadata, security, user support, and institutional continuity. Software requires maintenance, testing, documentation, dependency management, and succession. Collaborative platforms require moderation, governance, conflict resolution, and abuse prevention. Standards require revision. Community archives require stewardship relationships and often long-term trust. Sustainability therefore concerns the reproduction of the conditions that keep openness practically meaningful.

This problem is partly hidden by the low marginal cost of copying many digital objects. Copying a file can be cheap while producing, verifying, documenting, preserving, hosting, indexing, updating, and governing the resource remain costly. Hess and Ostrom's knowledge-commons framework is useful precisely because it directs attention to the institutional conditions surrounding knowledge resources rather than treating non-rivalry as sufficient for stable sharing (Hess and Ostrom 2007). Frischmann's analysis similarly emphasizes that shared infrastructure generates value through downstream use and therefore raises questions about how its maintenance is financed and governed (Frischmann 2012).

Definition 17.199 (Reproductive sustainability of an epistemic commons). The *reproductive sustainability of an epistemic commons* is its capacity to maintain the material, technical, institutional, relational, and human conditions required for continued access, contribution, verification, preservation, governance, and revision across the relevant temporal horizon.

Sustainability can fail through several mechanisms. Funding can disappear. Maintenance labor can become concentrated in a few exhausted contributors. A project can lack succession when key maintainers leave. Technical dependencies can become obsolete. Governance conflict can drive contributors away. Security incidents can make openness too costly to maintain. A platform can grow faster than its moderation capacity. A repository can preserve files while losing the expertise required to interpret them. These are economic failures of reproduction even when the nominal content remains available.

Sustainability also has distributive implications. Open resources can shift costs from users to maintainers, public institutions, volunteers, donors, or communities whose contributions are less visible than downstream benefits. A sustainability analysis should therefore ask who bears maintenance costs, who controls priorities, who receives downstream value, and whether contributors possess exit, voice, succession, and support mechanisms. Long-run openness depends on how these burdens and returns are organized.

Proposition 17.200 (Commons-sustainability condition). *An open epistemic arrangement is reproductively sustainable only to the extent that the resources, labor, governance, preservation, and succession conditions material to its continued operation are regenerated across time at a level adequate to its intended functions.*

The proposition does not imply indefinite preservation of every commons. Some projects are intentionally temporary; some should close when their purpose ends; others should be merged, archived, or replaced. Sustainability is evaluated relative

to the intended temporal horizon and function. The relevant failure arises when an arrangement depends on future continuity while its mode of openness systematically erodes the conditions required for that continuity.

17.15.7 Openness and Exploitation

Openness can broaden generative participation while also lowering the cost of appropriation by actors with greater compute, capital, distribution, legal capacity, or market access. This dual possibility is central to an epistemic economy. A shared dataset can enable distributed research and also support concentrated commercial products. Open-source software can reduce entry barriers and also become a critical dependency for organizations that return little maintenance capacity. Publicly accessible cultural or linguistic material can support education, preservation, and translation while also being aggregated into systems whose governance is distant from the contributing communities. The relevant analysis concerns the conversion pathways through which open contributions become downstream capability.

Section 17.9 defined generative exploitation through a stronger mechanism than unequal benefit alone. The same discipline applies here. Open reuse, commercial reuse, large-scale reuse, or asymmetric benefit does not by itself establish exploitation. A stronger diagnosis requires an appropriation or control mechanism together with a connected weakening of the source side's future generative capacity, alternatives, maintenance conditions, control, or practically relevant return.

Definition 17.201 (Openness-enabled generative appropriation). *Openness-enabled generative appropriation* is the conversion of contributions available through an open epistemic arrangement into downstream capability, value, or control by a position whose access to those contributions is materially enabled by the openness of the source arrangement.

Definition 17.201 is descriptive. It covers beneficial and problematic reuse. A public-health researcher can use open data to produce socially valuable analysis. A small firm can build on open software. A language community can reuse an open corpus for education. An organization can also aggregate open contributions at scale and create a proprietary service. Normative evaluation depends on the rights, expectations, governance, returns, source-side effects, and relevant justice claims in the case.

The most difficult cases arise when the source system is open partly because contributors or public institutions absorb production and maintenance costs, while downstream actors possess much stronger conversion capabilities. This can produce a pattern in which the commons supplies low-cost generative inputs to concentrated systems without receiving maintenance, attribution, governance, or capacity in return. Such a pattern can remain stable for a time because the commons is supported by public funds, volunteer labor, professional norms, or mission-driven institutions. Its apparent abundance can therefore conceal depletion of the conditions that generate the inputs.

Proposition 17.202 (Openness–exploitation non-equivalence). *Openness neither establishes nor excludes generative exploitation. An exploitation claim requires evidence that openness participates in an appropriation or control mechanism connected to a*

materially relevant weakening of the source configuration's continued generative conditions, alternatives, control, or return.

This proposition permits governance responses more differentiated than closing the commons. Attribution requirements, reciprocal licensing, public funding, maintenance obligations, benefit sharing, contributor governance, portability, public-interest access conditions, community stewardship, or differentiated permissions can address different mechanisms. The appropriate response depends on what is being shared, which contributors or communities are affected, how downstream value is created, and which form of source-side reproduction is at risk.

AI-mediated reuse makes these questions more salient because computational systems can aggregate large quantities of openly accessible material, compress prior contributions into reusable capability, and deploy that capability across domains. The present section establishes the commons-side diagnostic vocabulary. Section 17.16 and Chapter 18 examine the capability asymmetries and human–AI dependencies through which these conversion relations can become more consequential.

17.15.8 Plural Knowledge Systems

Open epistemic systems can connect heterogeneous knowledge traditions, languages, methods, evidential practices, institutions, and communities. Openness therefore raises a problem of plurality as well as access. A system that makes material widely available while requiring every contribution to pass through one dominant language, ontology, classification scheme, evidential convention, or institutional credential can remain formally open while narrowing the forms in which knowledge is recognizable. UNESCO's open-science framework explicitly includes respect for diversity of cultures and knowledge systems within the broader architecture of openness (UNESCO 2021). GRE treats this plurality as an institutional and translational problem rather than as evidence that standards of warrant are irrelevant.

The phrase *knowledge system* is used here operationally. It refers to a historically organized configuration of language, practices, categories, evidential resources, transmission relations, validation procedures, institutions, and repositories through which a community or field produces, preserves, interprets, and revises knowledge. Such systems can overlap substantially. Scientific disciplines, professional communities, local ecological practices, craft traditions, linguistic communities, public agencies, and Indigenous knowledge communities can each contain internally heterogeneous practices and can interact through multiple interfaces. The concept therefore does not require sealed or mutually incommensurable epistemic worlds.

Plurality creates both generative opportunity and translation risk. Different systems can preserve observations, distinctions, histories, or practical competencies that are absent elsewhere. Interaction can generate new questions, comparisons, methods, and interpretations. At the same time, translation can strip context, force categories into an unsuitable schema, detach claims from stewardship obligations, or convert local authority into external data without preserving the relations through which the knowledge acquired meaning. Section 17.13 showed why provenance and historical context matter for later re-epistemization; plural systems add the requirement that translation preserve the relevant epistemic and governance relations

across boundaries.

Definition 17.203 (Plural epistemic interoperability). *Plural epistemic interoperability* is the capacity of heterogeneous knowledge systems to exchange, compare, translate, contest, or combine epistemic material while preserving the distinctions in meaning, provenance, authority, uncertainty, stewardship, and validation that are material to responsible use.

Interoperability in Definition 17.203 is therefore stronger than technical compatibility and weaker than full conceptual unification. Two systems can exchange selected observations while retaining different categories. A scientific database can include community-governed fields whose use requires additional context. Multilingual resources can preserve source-language terms where translation would collapse distinctions. Cross-disciplinary projects can maintain separate evidential standards while defining explicit interfaces for comparison. These arrangements make plurality operational without assuming that every difference should disappear.

Epistemic plurality also requires contestability. Longino's account of social knowledge emphasizes critical interaction and the importance of multiple perspectives for identifying background assumptions in inquiry (Longino 1990). Within an open epistemic system, plurality becomes generative when participants can make differences visible, challenge translations, revise shared categories, and preserve unresolved disagreement where available evidence does not support convergence. Plurality does not imply that every claim has equal warrant. Claims remain answerable to the evidential, interpretive, practical, and normative standards appropriate to the domain, together with the cross-system procedures through which disagreement is evaluated.

Proposition 17.204 (Plurality-preservation condition). *An open epistemic system preserves generative plurality when its translation, interoperability, and governance arrangements permit heterogeneous epistemic contributions to remain recognizable and contestable without requiring premature reduction to a single language, category system, institutional authority, or evaluative metric.*

The condition is demanding because openness and standardization often interact. Shared standards can be essential for interoperability, yet they can also make some categories easy to record and others difficult to express. Common languages can widen communication while increasing the translation burden borne by minority-language contributors. Open repositories can preserve diverse materials while search and ranking systems make only a subset visible. A plural system therefore requires attention to the interfaces where openness is converted into visibility, legibility, and authority.

A final distinction concerns the relation between a knowledge commons and an open epistemic system. A commons has a sufficiently identifiable shared object or configuration together with governance relations through which access, contribution, maintenance, and revision are organized. An open epistemic system can be more distributed. It can connect several commons, public institutions, scholarly communities, private services, standards bodies, archives, educational organizations, and informal contributor networks without placing the entire configuration under one governance regime. Openness at the system level therefore concerns the permeability and revisability of interfaces among partially autonomous components.

Definition 17.205 (Open epistemic system). An *open epistemic system* is a relational configuration of epistemic resources, participants, institutions, infrastructures, and interfaces in which multiple positions can enter, contribute, retrieve, translate, verify, revise, or recombine epistemic material across organizational or community boundaries under an identifiable profile of access and governance conditions.

Definition 17.205 allows selective closure within a broadly open system. A repository can protect sensitive data while publishing metadata and aggregate results. A community can govern culturally consequential material through differentiated permissions while participating in wider scientific or educational exchange. A platform can expose interoperable standards while retaining some operational components under centralized control. The analytical task is to locate the interfaces through which participation is enabled, restricted, or converted rather than assigning a single open/closed label to the whole configuration.

System-level openness also depends on capability distribution. Formally available interfaces can remain functionally closed to participants who lack language, compute, verification resources, legal capacity, credentials, or time. Conversely, a system with differentiated permissions can support broad generative participation when the restrictions are matched to stewardship responsibilities and usable pathways remain available for relevant participants. The openness profile from Definition 17.189 therefore applies across system interfaces as well as individual resources.

Proposition 17.206 (Open-system capability condition). *The generative openness of an epistemic system depends on the practical capability of relevant positions to traverse its material interfaces for contribution, access, verification, revision, or recombination, together with governance arrangements that keep those pathways sufficiently maintainable and contestable for the system's intended purposes.*

Knowledge commons and open epistemic systems can now be placed within the wider chapter architecture. Open access expands the positions from which participation can begin. Shared infrastructure supplies reusable generative conditions. Commons governance organizes contribution and revision. Attribution preserves contribution histories. Reciprocity concerns the circulation of return. Sustainability concerns reproduction of the commons itself. Exploitation analysis asks whether openness is converted into one-sided appropriation that weakens continued generation. Plural interoperability preserves heterogeneous epistemic sources while enabling bounded translation and contestation.

These dimensions also expose the limit of treating openness as a complete answer to epistemic inequality. Participants can face radically different capacities to search, verify, compute, aggregate, translate, finance, and commercialize the same open resource. The economic consequences of openness therefore depend on the capability distribution surrounding the commons. This point provides the immediate interface to artificial intelligence. Machine systems can expand access, translation, search, synthesis, and generative production while also increasing the scale at which open material is aggregated and converted into concentrated capability. Section 17.16 turns to that interface by examining machine knowledge generation, symbolic abundance, capability concentration, human–AI asymmetry, and epistemic dependence.

17.16 Artificial Intelligence within the Epistemic Economy

This section closes Chapter 17 by locating contemporary artificial intelligence within the epistemic economy developed across Sections 17.1–17.15. The objective is bounded. Artificial-intelligence systems already alter the cost, speed, scale, accessibility, and institutional organization of epistemic production, yet the resulting changes cannot be understood through output volume alone. They interact with verification, attention, orientation, infrastructure, knowledge capital, exploitation, justice, preservation, learning, and commons governance. The present section therefore examines six interfaces: machine knowledge generation, symbolic abundance, capability concentration, human–AI asymmetry, epistemic dependence, and the conditions under which these epistemic differences become relevant to the more extensive analysis of radical capability asymmetry in Chapter 18. The method is relational and mechanism-sensitive. AI is treated as a heterogeneous set of computational systems embedded in organizational, infrastructural, legal, and human relations rather than as an autonomous economic force with a single effect.

The terminology requires an initial qualification. The phrase *machine knowledge generation* is used operationally to describe artificial systems that generate outputs capable of entering processes of inquiry, learning, decision, design, interpretation, or verification. It does not establish that the system possesses knowledge in the same sense as a human knower, nor does it infer understanding, subjecthood, responsibility, or epistemic authority from fluent output. Section 17.3.3 already distinguished AI-generated symbolic artifacts from warranted knowledge, and Bender and colleagues provide an important linguistic caution against equating fluent language-model output with grounded understanding (Bender et al. 2021). The present section retains that distinction while asking what changes economically when such output becomes cheap, scalable, and institutionally integrated.

Contemporary evidence makes the issue more than speculative. The 2026 Stanford AI Index documents continuing gains in frontier-system performance across several benchmarked domains while also emphasizing concentration of frontier development and computational infrastructure among a relatively small set of organizations (Stanford Institute for Human-Centered Artificial Intelligence 2026). Experimental and workplace studies have also found productivity gains from generative-AI assistance in selected writing and customer-support tasks, with heterogeneous effects across workers and evidence consistent with knowledge diffusion in some settings (Noy and Zhang 2023; Brynjolfsson et al. 2025). These findings support neither a general claim of human replacement nor a uniform productivity effect. They establish that AI-mediated capability can already alter the organization of epistemic work in some domains, making the distribution and governance of complementary capacities an economic question.

Table 17.16 summarizes the six interfaces developed in this section.

17.16.1 Machine Knowledge Generation

Artificial-intelligence systems can participate in epistemic production through more than direct answer generation. They can retrieve and reorganize information, sum-

Table 17.16: Artificial intelligence within the epistemic economy

Interface	AI-mediated change	Economic and epistemic question
Machine knowledge generation	Rapid production, transformation, retrieval, synthesis, and exploration of candidate epistemic material	Which outputs become warranted, attributable, reusable, and responsibility-bearing within a specified practice?
Symbolic abundance	Lower cost of producing persuasive text, images, code, classifications, summaries, and other representations	Which complementary capacities become scarce as symbolic production expands?
Capability concentration	Unequal control of models, compute, data, specialized labor, distribution interfaces, evaluation, and supporting infrastructure	Where does concentrated capability create durable advantage, dependence, or gatekeeping capacity?
Human–AI asymmetry	Task-relative differences in speed, scale, memory, computation, generation, context, judgment, embodiment, and responsibility	Which asymmetries are consequential for participation, verification, delegation, and institutional authority?
Epistemic dependence	Reliance on AI-mediated generation, retrieval, interpretation, classification, or decision support	When does useful specialization become difficult-to-contest or difficult-to-exit dependence?
Radical capability interface	Persistence and coupling of epistemic asymmetries with broader productive and institutional capabilities	When does an epistemic difference require analysis as a wider economic capability asymmetry?

marize documents, translate across languages, generate code, propose classifications, produce synthetic examples, identify patterns, construct candidate explanations, assist search, and support iterative exploration. Some systems can also invoke tools, execute multi-step procedures, or interact with software environments. These activities can reduce the cost of producing intermediate epistemic objects even where final judgment remains human or institutionally governed.

The economic significance lies partly in the change to the production function of inquiry. A researcher can examine more candidate formulations before committing to one. A learner can request multiple explanations. A firm can generate alternative drafts or analyses at low marginal cost. A public institution can use automated systems to process large document collections. These changes can expand search breadth, reduce some entry costs, or redistribute labor from initial production toward specification, selection, checking, and integration. Their value remains field-dependent because the relevant error costs, verification requirements, and institutional responsibilities differ substantially across uses.

Definition 17.207 (Machine-mediated epistemic generation). *Machine-mediated epistemic generation* is a process in which an artificial computational system produces, transforms, retrieves, organizes, or proposes candidate epistemic material that en-

ters a human, organizational, or collective pathway of inquiry, learning, interpretation, verification, design, or decision.

Definition 17.207 locates the system inside a wider pathway. The generated material can be useful without independently carrying the status of warranted knowledge. A translation may widen access even when it requires domain review. A model-generated hypothesis may redirect experimentation even when it is eventually rejected. Code can serve as a prototype before audit. A synthetic example can support pedagogy without functioning as empirical evidence. Economic value can therefore arise at intermediate stages of epistemic production.

This pathway perspective also clarifies responsibility. When an AI-generated artifact is incorporated into a consequential decision, its practical standing depends on the institutions and persons that select, verify, authorize, communicate, or act upon it. The presence of machine generation does not erase those relations. It can, however, make them harder to see when the artifact arrives in polished form or when production is distributed across model providers, application developers, organizational procedures, and end users.

Proposition 17.208 (Epistemic incorporation condition). *A machine-generated artifact becomes part of a warranted epistemic process only to the extent that the relevant practice supplies the evidential, interpretive, verificatory, provenance, authorization, and responsibility conditions appropriate to the artifact's intended function.*

Proposition 17.208 extends the output–knowledge distinction from Section 17.3.3. It also explains why the same model output can have different epistemic standing across contexts. A speculative research prompt, a classroom explanation, an internal draft, an engineering calculation, and a medical recommendation occupy different responsibility and verification architectures. The economic analysis should therefore follow how an output is incorporated rather than infer its standing from the generating technology alone.

Machine-mediated generation can also change who is able to participate. Lower-cost translation, explanation, coding assistance, and document synthesis can reduce some technical or linguistic barriers. The workplace evidence discussed above suggests that assistance can sometimes produce larger measured gains among initially lower-performing or less experienced workers (Noy and Zhang 2023; Brynjolfsson et al. 2025). Section 17.14.5 nevertheless established that assisted performance and learning remain distinct. A system can increase immediate output while leaving the user's later independent capability largely unchanged, or it can participate in a learning relation that changes future human capability. This distinction becomes central once AI-mediated generation is used continuously rather than episodically.

17.16.2 Symbolic Abundance

Artificial intelligence intensifies the symbolic-abundance problem developed in Section 17.3. Text, images, audio, video, code, diagrams, summaries, classifications, and polished explanations can be produced at scales and speeds that weaken older inferences from production cost to credibility, expertise, originality, or organizational investment. The resulting abundance can broaden expression and experimentation while increasing the amount of material through which people and institutions must

search.

The relevant scarcity shift is therefore relational. When initial production becomes inexpensive, the scarce complements can move toward source evaluation, verification, provenance, attention, orientation, integration, long-horizon observation, and accountable judgment. This shift does not imply that total verification expenditure must rise in every setting. Automation can also reduce checking costs through consistency tests, retrieval, comparison, or anomaly detection. The analytical question is whether verification and selection capacity expand at a rate and quality sufficient for the uses created by the increased supply of symbolic output.

Definition 17.209 (AI-mediated symbolic multiplication). *AI-mediated symbolic multiplication* is the expansion in the volume, variety, speed, or replicability of symbolic representations made feasible by artificial systems, together with the resulting change in the relative scarcity of the capacities needed to authenticate, interpret, rank, verify, preserve, and responsibly use those representations.

The definition emphasizes relative scarcity rather than output volume alone. In one domain, abundance may make search and curation the main bottlenecks. In another, verification may dominate because errors are costly. In a third, provenance may become critical because synthetic and human-produced materials are difficult to distinguish by surface form. In a fourth, abundance may increase accessibility enough that the net effect is strongly positive despite higher filtering demands.

Provenance illustrates the institutional response. The C2PA specification provides one contemporary architecture for attaching cryptographically verifiable provenance assertions and content bindings to digital assets (Coalition for Content Provenance and Authenticity 2026). Such mechanisms can support reconstruction of production history, but provenance does not by itself establish that the represented claim is true, valuable, or normatively acceptable. Section 17.13 developed the same distinction more generally: reconstructible lineage is a condition for some forms of re-epistemization, while warrant requires additional evidential and interpretive work.

Proposition 17.210 (Abundance–bottleneck relocation). *When artificial systems reduce the cost of producing a class of epistemic or symbolic artifacts more rapidly than the cost of evaluating, integrating, verifying, or governing them, the principal bottleneck in that pathway can shift from production toward one or more complementary capacities.*

This proposition is conditional because AI can improve complements as well as production. A system that generates code can also test it; a retrieval system can both expand candidate sources and rank them; an automated translation system can increase both output and access. The economic problem concerns the configuration of the whole pathway and the distribution of the complementary capacities, not a presumed one-directional effect of abundance.

Symbolic abundance also interacts with attention and orientation. Section 17.4 showed that attention allocation concerns selection among candidate objects, while Sections 17.5 and 17.6 treated question formation and epistemic orientation. AI can participate in all three layers: it can enlarge the candidate set, rank or recommend what becomes visible, and generate suggestions about what questions appear worth

asking. This combination gives systems that mediate generation and selection a different institutional significance from tools that merely accelerate a fixed task.

17.16.3 Capability Concentration

The diffusion of AI-enabled services can coexist with concentration in the infrastructures that make those services possible. A large number of users can access similar interfaces while the underlying frontier models, computational facilities, specialized chips, training pipelines, datasets, distribution platforms, and technical expertise remain concentrated among fewer organizations. The Stanford AI Index reports that industry produced more than ninety percent of notable AI models in 2025 and documents continuing growth and concentration in the computational resources supporting frontier development (Stanford Institute for Human-Centered Artificial Intelligence 2026). The economic significance of this concentration depends on the relations through which infrastructural control becomes advantage, dependency, or power.

Capability concentration should therefore be decomposed. Control of compute differs from control of a model. Model control differs from control of a distribution interface. Access to large datasets differs from the ability to curate, clean, evaluate, or legally use them. Specialized research labor, capital, energy supply, cloud infrastructure, safety and evaluation capacity, and customer access can each become complementary bottlenecks. A firm can possess a strong model while depending on another organization for cloud infrastructure; a public institution can possess data while lacking compute and technical staff; an open model can reduce one access barrier while still requiring expensive deployment infrastructure.

Definition 17.211 (AI epistemic capability stack). An *AI epistemic capability stack* is the configuration of models, compute, data, software, specialized labor, evaluation capacity, distribution interfaces, organizational routines, legal permissions, and supporting infrastructures through which an AI-mediated epistemic function is made practically available and maintainable.

Definition 17.211 makes concentration multidimensional. A capability can be distributed at one layer and concentrated at another. Open weights can coexist with concentrated chip supply. Broad user access can coexist with proprietary training data. Multiple model providers can coexist with concentration in cloud or distribution infrastructure. The relevant economic object is therefore the architecture of complements and control across the stack.

Definition 17.212 (Capability-concentration profile). An *AI capability-concentration profile* records the distribution of ownership, control, access, substitution possibilities, and practical decision rights across the material layers of an AI epistemic capability stack for a specified field or function.

A profile supports more precise comparison than a general statement that “AI is concentrated.” The same ecosystem can display concentration in frontier training, competition in application services, public provision of selected datasets, open technical standards, and distributed downstream innovation. These dimensions can change at different rates and can have different effects on entry, bargaining, verification, and institutional autonomy.

Concentration does not establish power by itself. Chapter 16 and Section 17.7.7 require an identifiable conversion mechanism. Control of compute can become power when another position's feasible action depends on access that can be conditioned or withdrawn. Control of a model can become power when switching costs, integration costs, data lock-in, or performance differences make alternatives materially weaker. Distribution control can become power when visibility or market access depends on a gatekeeping interface. Conversely, concentration can sometimes support high fixed-cost activities, shared reliability, or coordination without producing a corresponding relation of domination.

Proposition 17.213 (Stack-concentration conversion condition). *Concentration in an AI capability stack becomes power-relevant when control over a consequential and weakly substitutable layer can condition another position's access, alternatives, verification capacity, participation, or future generative possibilities.*

The proposition links AI to the infrastructure and power analysis already developed without resolving the broader distributive questions of model ownership, compute ownership, or AI-generated surplus. Those objects belong to Chapter 18, where capability concentration is analyzed together with production, labor, distribution, and participation.

17.16.4 Human–AI Asymmetry

Human–AI comparison is easily distorted when many dimensions are compressed into a single ranking. Artificial systems can exceed individual humans on some measures of computational speed, storage, search breadth, symbolic generation, or standardized task performance, while remaining unreliable or weak in other tasks and depending on human-designed infrastructures, training processes, institutional goals, and deployment contexts. The 2026 AI Index documents both substantial capability gains and continuing unevenness across tasks and evaluations (Stanford Institute for Human-Centered Artificial Intelligence 2026). GRE therefore treats human–AI asymmetry as task-relative, dimension-specific, and historically changing.

Relevant dimensions include generation speed, volume of retrievable material, computational throughput, reproducibility, memory architecture, multimodal transformation, tool use, and coordination across machine instances. Human positions can differ along other dimensions including embodied access to local environments, biographical continuity, social membership, practical responsibility, normative accountability, situated interpretation, care relations, and the ability to bear consequences within institutions. These categories should not be converted into a universal hierarchy. Their economic relevance depends on the function under analysis.

Definition 17.214 (Task-relative human–AI capability asymmetry). *A task-relative human–AI capability asymmetry is a directional difference between a human position and an AI-mediated position in one or more capabilities material to a specified epistemic task, evaluated under stated conditions of access, tools, time, verification, and institutional support.*

The phrase *AI-mediated position* is deliberate. A deployed system normally includes more than a model. It can include retrieval systems, external tools, databases, interfaces, monitoring procedures, human operators, and organizational support.

Comparing an unaided person with a fully provisioned machine service can answer some questions, while comparing a human team using AI with a team lacking it can answer others. The unit of comparison should match the decision being studied.

Proposition 17.215 (Asymmetry non-totalization). *Capability advantage on one or several specified epistemic dimensions does not by itself establish general superiority, epistemic authority, decision legitimacy, or substitution across other dimensions whose requirements differ.*

Proposition 17.215 is important for both analysis and governance. High performance on standardized tests can be economically consequential without proving reliability in an open environment. Rapid generation can increase productive capacity without transferring responsibility. Broad retrieval can widen the evidence base while still requiring contextual interpretation. A system that supports one user's learning can weaken another user's independent practice if it substitutes for activities through which capability was previously formed. These possibilities require mechanism-specific study.

Human–AI asymmetry is also relational because access is unequally distributed. A person with high-quality models, compute, domain data, integration support, and evaluation expertise can occupy a very different epistemic position from a person using a weaker public interface. The comparison therefore includes asymmetries among humans that are mediated by AI. Section 17.7 already defined AI-mediated epistemic asymmetry in this broader sense. The present subsection adds the machine relation while preserving the wider institutional distribution around it.

17.16.5 Epistemic Dependence

AI-mediated capability can become economically significant through dependence. Dependence appears when a person, organization, or institution relies on an AI-mediated system for an epistemic function whose interruption, degradation, manipulation, or withdrawal would materially affect its capacity to act. Such reliance can be productive. Division of epistemic labor already characterizes medicine, engineering, law, science, accounting, public administration, and complex production. AI can extend that division by providing translation, search, synthesis, classification, coding, prediction, or decision support at lower cost or greater scale.

The governance problem begins where dependence becomes difficult to verify, contest, substitute, or exit. A professional can become reliant on a proprietary system whose internal changes are difficult to observe. An organization can redesign workflows around an external model provider and then face high switching costs. Students can rely on generated explanations without acquiring complementary verification skills. Public agencies can depend on vendor-controlled tools for classification or prioritization while lacking internal capacity to audit outputs. Researchers can become dependent on computational services whose pricing or access conditions determine which analyses remain feasible.

Definition 17.216 (AI-mediated epistemic dependence). *AI-mediated epistemic dependence* is a condition in which a position's ability to perform an economically consequential epistemic function materially relies on an artificial-intelligence system or its supporting infrastructure and the relevant function cannot be replaced, verified,

contested, or reconstructed at acceptable cost within the decision horizon.

The definition specializes the broader analysis of epistemic dependence in Chapter 16. It includes dependence on model access, compute, proprietary retrieval systems, vendor-maintained classifications, generated code, synthetic data pipelines, or AI-mediated organizational routines. It does not classify ordinary tool use as dependence whenever the tool is easily replaceable or the relevant function remains independently reconstructible.

Dependence also interacts with learning. Section 17.14.5 distinguished assistance from transformation of the learner. When AI repeatedly carries a capability externally, an organization can increase current performance while its internal human capability stagnates or declines. In other cases, assistance can accelerate learning and make users more capable of independent verification or problem solving. The direction depends on task design, feedback, transparency, deliberate practice, organizational incentives, and opportunities to perform the relevant work without assistance.

Proposition 17.217 (AI-dependence vulnerability condition). *AI-mediated epistemic dependence becomes a source of vulnerability when consequential functions rely on a narrow or weakly substitutable support while internal verification, contestation, portability, recovery, or exit capacities remain inadequate for plausible failures or changes in access.*

The proposition does not imply that autonomy requires self-sufficiency. Collective epistemic systems depend on specialization precisely because reproducing every capability locally would be wasteful or impossible. The relevant design question concerns the distribution of fallback capacity, auditability, substitution, institutional memory, and decision rights. Some organizations may need independent verification capacity without independent model-development capacity. Others may require portable data and interoperable interfaces more urgently than full technical transparency. Dependence should therefore be governed in relation to consequence and plausible failure modes.

AI-mediated dependence also creates a temporal issue. Once records, workflows, educational practices, and institutional expectations are reorganized around AI systems, reversal can become costly even when an alternative technology exists. Historical dependence can therefore be deeper than contractual dependence at a single moment. The chapter's earlier analyses of knowledge capital, infrastructure, preservation, and generative transformation provide the relevant vocabulary: AI systems can become part of the conditions through which later epistemic possibility is generated.

17.16.6 Artificial Intelligence and Radical Capability Asymmetry

The five interfaces developed above identify the point at which an epistemic-economy analysis begins to require a broader account of artificial intelligence. Machine-mediated generation changes the production of candidate epistemic material. Symbolic multiplication can relocate bottlenecks toward verification, attention, orientation, and provenance. Capability stacks can become concentrated at different infrastructural layers. Human–AI capability differences are multidimensional

and task-relative. Dependence can become productive specialization or a source of vulnerability depending on substitution, verification, contestability, and exit.

These phenomena remain epistemic while their consequences increasingly extend beyond epistemic production. A system that generates knowledge-related outputs can alter labor demand, organizational design, investment, education, distribution, institutional authority, and access to productive capacity. Control of models or compute can affect entry and bargaining. AI-mediated decision support can influence allocation. Persistent capability differences can affect participation and social position. At this point the relevant object is wider than the epistemic economy considered in isolation.

Chapter 18 uses the term *radical capability asymmetry* for that wider problem. The present chapter does not define the concept exhaustively because its economic meaning depends on productive, distributive, institutional, labor, and participatory relations developed there. It can nevertheless specify the interface conditions that make such analysis necessary.

Definition 17.218 (AI capability-asymmetry escalation profile). An *AI capability-asymmetry escalation profile* records the extent to which AI-mediated capability differences are multidimensional, persistent, cumulatively reinforced, infrastructure-supported, weakly substitutable, institutionally embedded, and consequential for economic action beyond the immediate epistemic task.

The profile is diagnostic rather than predictive. A large benchmark gap can co-exist with easy substitution and limited economic consequence. A modest technical difference can become structurally important when it controls a widely used infrastructure. Rapid diffusion can reduce one asymmetry while creating another around verification or coordination. Open systems can broaden access while still depending on concentrated compute. The profile therefore asks how differences are reproduced and converted rather than treating technological performance as a direct measure of social consequence.

Proposition 17.219 (Epistemic-economy escalation condition). *An AI-mediated epistemic asymmetry becomes a candidate for analysis as radical capability asymmetry when its persistence and conversion mechanisms materially alter access to productive capacity, institutional participation, bargaining, decision influence, or future generative possibilities beyond the epistemic function in which the asymmetry first appears.*

Proposition 17.219 establishes the chapter boundary. It prevents every AI advantage from being labeled radical while also avoiding an artificial separation between knowledge and the broader economy. Some AI systems may remain specialized tools whose effects are local. Others may become infrastructures through which multiple sectors organize production, learning, coordination, and decision. The distinction should be established through observed relations, persistence, dependence, substitution, and conversion mechanisms.

The architecture of Chapter 17 can now be closed. Knowledge operates economically as resource, capability, relation, infrastructure, power-relevant position, and generative condition. Scarcity can persist under abundance because verification, attention, orientation, trust, interpretation, and access remain limited. Curiosity and aesthetic judgment help form the directions of inquiry. Epistemic asymmetry can

become power through identifiable conversion mechanisms. Knowledge capital can accumulate, while generative exploitation can appropriate and weaken the conditions of future generation. Institutions and infrastructures stabilize epistemic activity across time. Justice concerns visibility, voice, classification, evidential resources, interpretive authority, contestability, preservation, and future re-recognizability. Re-epistemization preserves the possibility that inherited records can be reconstructed and reinterpreted. Knowing can transform the knower, and commons can organize shared epistemic resources under plural governance.

Artificial intelligence changes the scale and coupling of these relations. Its significance within GRE therefore cannot be reduced to a question of whether machines “know.” The economic question is how artificial capability enters generative relations: who can access it, who controls its infrastructure, which human capabilities it complements or displaces, how dependence forms, where verification and responsibility reside, which returns are concentrated or shared, and how participation remains possible under widening capability differences. Chapter 18 takes these questions as its primary object by analyzing artificial productive capacity and radical capability asymmetry across labor, ownership, surplus, redistribution, subjecthood, human–AI relations, governance, and long-horizon economic order.

References

- Anderson, Elizabeth S. (1999). “What Is the Point of Equality?” In: *Ethics* 109.2, pp. 287–337. DOI: [10.1086/233897](https://doi.org/10.1086/233897).
- Archer, Margaret S. (2000). *Being Human: The Problem of Agency*. Cambridge: Cambridge University Press. DOI: [10.1017/CB09780511488733](https://doi.org/10.1017/CB09780511488733).
- Aristotle (2016). *Metaphysics*. Trans. by C. D. C. Reeve. Indianapolis, IN: Hackett Publishing Company.
- Arrow, Kenneth J. (1962). “Economic Welfare and the Allocation of Resources for Invention”. In: *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Princeton, NJ: Princeton University Press, pp. 609–626.
- Becker, Gary S. (1964). *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*. New York: National Bureau of Economic Research.
- Bender, Emily M., Timnit Gebru, Angelina McMillan-Major, and Margaret Mitchell (2021). “On the Dangers of Stochastic Parrots: Can Language Models Be Too Big?” In: *Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency*, pp. 610–623. DOI: [10.1145/3442188.3445922](https://doi.org/10.1145/3442188.3445922).
- Benkler, Yochai (2002). “Coase’s Penguin, or, Linux and The Nature of the Firm”. In: *Yale Law Journal* 112.3, pp. 369–446. DOI: [10.2307/1562247](https://doi.org/10.2307/1562247).
- Berlyne, D. E. (1954). “A Theory of Human Curiosity”. In: *British Journal of Psychology. General Section* 45.3, pp. 180–191. DOI: [10.1111/j.2044-8295.1954.tb01243.x](https://doi.org/10.1111/j.2044-8295.1954.tb01243.x).
- Bordalo, Pedro, Nicola Gennaioli, and Andrei Shleifer (2012). “Salience Theory of Choice Under Risk”. In: *The Quarterly Journal of Economics* 127.3, pp. 1243–1285. DOI: [10.1093/qje/qjs018](https://doi.org/10.1093/qje/qjs018).
- Bourdieu, Pierre (1984). *Distinction: A Social Critique of the Judgement of Taste*. Trans. by Richard Nice. Cambridge, MA: Harvard University Press.
- (1991). *Language and Symbolic Power*. Ed. by John B. Thompson. Cambridge, MA: Harvard University Press.
- Bowker, Geoffrey C. and Susan Leigh Star (1999). *Sorting Things Out: Classification and Its Consequences*. Cambridge, MA: MIT Press. DOI: [10.7551/mitpress/6352.001.0001](https://doi.org/10.7551/mitpress/6352.001.0001).
- Brynjolfsson, Erik, Danielle Li, and Lindsey Raymond (2025). “Generative AI at Work”. In: *The Quarterly Journal of Economics* 140.2, pp. 889–942. DOI: [10.1093/qje/qjae044](https://doi.org/10.1093/qje/qjae044).
- Burrell, Jenna (2016). “How the Machine ‘Thinks’: Understanding Opacity in Machine Learning Algorithms”. In: *Big Data & Society* 3.1. DOI: [10.1177/2053951715622512](https://doi.org/10.1177/2053951715622512).

- Bush, Vannevar (1945). *Science: The Endless Frontier: A Report to the President*. Washington, DC: United States Office of Scientific Research and Development. URL: https://www.nsf.gov/about/history/EndlessFrontier_w.pdf.
- Coalition for Content Provenance and Authenticity (2026). *Content Credentials: C2PA Technical Specification, Version 2.4*. URL: https://spec.c2pa.org/specifications/specifications/2.4/specs/C2PA_Specification.html (visited on 09/18/2026).
- Desrosières, Alain (1998). *The Politics of Large Numbers: A History of Statistical Reasoning*. Trans. by Camille Naish. Cambridge, MA: Harvard University Press.
- Dewey, John (1910). *How We Think*. Boston: D. C. Heath & Company.
- (1922). *Human Nature and Conduct: An Introduction to Social Psychology*. New York: Henry Holt and Company.
 - (1934). *Art as Experience*. New York: Minton, Balch & Company.
- Eglash, Ron (2016). “An Introduction to Generative Justice”. In: *Teknokultura. Revista de Cultura Digital y Movimientos Sociales* 13.2, pp. 369–404. DOI: [10.5209/rev_TEKN.2016.v13.n2.52847](https://doi.org/10.5209/rev_TEKN.2016.v13.n2.52847).
- Eglash, Ron, Kwame P. Robinson, Audrey Bennett, Lionel Robert, and Mathew Garvin (2024). “Computational Reparations as Generative Justice: Decolonial Transitions to Unalienated Circular Value Flow”. In: *Big Data & Society* 11.1. DOI: [10.1177/20539517231221732](https://doi.org/10.1177/20539517231221732).
- Espeland, Wendy Nelson and Michael Sauder (2007). “Rankings and Reactivity: How Public Measures Recreate Social Worlds”. In: *American Journal of Sociology* 113.1, pp. 1–40. DOI: [10.1086/517897](https://doi.org/10.1086/517897).
- Fanelli, Daniele (2012). “Negative Results Are Disappearing from Most Disciplines and Countries”. In: *Scientometrics* 90.3, pp. 891–904. DOI: [10.1007/s11192-011-0494-7](https://doi.org/10.1007/s11192-011-0494-7).
- Franco, Annie, Neil Malhotra, and Gabor Simonovits (2014). “Publication Bias in the Social Sciences: Unlocking the File Drawer”. In: *Science* 345.6203, pp. 1502–1505. DOI: [10.1126/science.1255484](https://doi.org/10.1126/science.1255484).
- Frickel, Scott, Sahra Gibbon, Jeff Howard, Joanna Kempner, Gwen Ottinger, and David J. Hess (2010). “Undone Science: Charting Social Movement and Civil Society Challenges to Research Agenda Setting”. In: *Science, Technology, & Human Values* 35.4, pp. 444–473. DOI: [10.1177/0162243909345836](https://doi.org/10.1177/0162243909345836).
- Fricker, Miranda (2007). *Epistemic Injustice: Power and the Ethics of Knowing*. Oxford: Oxford University Press. DOI: [10.1093/acprof:oso/9780198237907.001.0001](https://doi.org/10.1093/acprof:oso/9780198237907.001.0001).
- Frischmann, Brett M. (2012). *Infrastructure: The Social Value of Shared Resources*. New York: Oxford University Press. DOI: [10.1093/acprof:oso/9780199895656.001.0001](https://doi.org/10.1093/acprof:oso/9780199895656.001.0001).
- Gebru, Timnit, Jamie Morgenstern, Briana Vecchione, Jennifer Wortman Vaughan, Hanna Wallach, Hal Daumé III, and Kate Crawford (2021). “Datasheets for Datasets”. In: *Communications of the ACM* 64.12, pp. 86–92. DOI: [10.1145/3458723](https://doi.org/10.1145/3458723).
- Getzels, Jacob W. and Mihaly Csikszentmihalyi (1976). *The Creative Vision: A Longitudinal Study of Problem Finding in Art*. New York: John Wiley & Sons.
- Gibson, James J. (1979). *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.

- Hayek, F. A. (1945). "The Use of Knowledge in Society". In: *The American Economic Review* 35.4, pp. 519–530.
- Hess, Charlotte and Elinor Ostrom, eds. (2007). *Understanding Knowledge as a Commons: From Theory to Practice*. Cambridge, MA: MIT Press. ISBN: 9780262083577.
- Hidi, Suzanne and K. Ann Renninger (2006). "The Four-Phase Model of Interest Development". In: *Educational Psychologist* 41.2, pp. 111–127. DOI: [10 . 1207 / s15326985ep4102_4](https://doi.org/10.1207/s15326985ep4102_4).
- Honneth, Axel (2001). "Invisibility: On the Epistemology of 'Recognition'". In: *Aristotelian Society Supplementary Volume* 75.1, pp. 111–126. DOI: [10 . 1111 / 1467 - 8349 . 00081](https://doi.org/10.1111/1467-8349.00081).
- Hume, David (1985). *Essays: Moral, Political, and Literary*. Ed. by Eugene F. Miller. Indianapolis, IN: Liberty Fund.
- Kant, Immanuel (1987). *Critique of Judgment*. Trans. by Werner S. Pluhar. Indianapolis, IN: Hackett Publishing Company.
- Koselleck, Reinhart (2004). *Futures Past: On the Semantics of Historical Time*. Trans. by Keith Tribe. New York: Columbia University Press.
- Kroll, Joshua A., Joanna Huey, Solon Barocas, Edward W. Felten, Joel R. Reidenberg, David G. Robinson, and Harlan Yu (2017). "Accountable Algorithms". In: *University of Pennsylvania Law Review* 165.3, pp. 633–705.
- Kuhn, Thomas S. (1962). *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
- Lave, Jean and Etienne Wenger (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press. DOI: [10 . 1017 / CB09780511815355](https://doi.org/10.1017/CB09780511815355).
- Leder, Helmut, Benno Belke, Andries Oeberst, and Dorothee Augustin (2004). "A Model of Aesthetic Appreciation and Aesthetic Judgments". In: *British Journal of Psychology* 95.4, pp. 489–508. DOI: [10 . 1348 / 0007126042369811](https://doi.org/10.1348/0007126042369811).
- Litman, Jordan A., Tiffany L. Hutchins, and Ryan K. Russon (2005). "Epistemic Curiosity, Feeling-of-Knowing, and Exploratory Behaviour". In: *Cognition and Emotion* 19.4, pp. 559–582. DOI: [10 . 1080 / 02699930441000427](https://doi.org/10.1080/02699930441000427).
- Loewenstein, George (1994). "The Psychology of Curiosity: A Review and Reinterpretation". In: *Psychological Bulletin* 116.1, pp. 75–98. DOI: [10 . 1037 / 0033 - 2909 . 116 . 1 . 75](https://doi.org/10.1037/0033-2909.116.1.75).
- Longino, Helen E. (1990). *Science as Social Knowledge: Values and Objectivity in Scientific Inquiry*. Princeton, NJ: Princeton University Press.
- MacKenzie, Donald (2006). *An Engine, Not a Camera: How Financial Models Shape Markets*. MIT Press. ISBN: 9780262134606.
- Mauss, Marcel (1990). *The Gift: The Form and Reason for Exchange in Archaic Societies*. Trans. by W. D. Halls. London: Routledge. ISBN: 9780415044875.
- McAllister, James W. (1996). *Beauty and Revolution in Science*. Ithaca, NY: Cornell University Press.
- Mead, George Herbert (1934). *Mind, Self, and Society: From the Standpoint of a Social Behaviorist*. Ed. by Charles W. Morris. Chicago: University of Chicago Press.
- Merleau-Ponty, Maurice (2012). *Phenomenology of Perception*. Trans. by Donald A. Landes. Abingdon, Oxon: Routledge.

- Murmann, Johann Peter (2003). *Knowledge and Competitive Advantage: The Coevolution of Firms, Technology, and National Institutions*. Cambridge: Cambridge University Press. DOI: [10.1017/CB09780511510953](https://doi.org/10.1017/CB09780511510953).
- Nelson, Richard R. (1994). "The Co-evolution of Technology, Industrial Structure, and Supporting Institutions". In: *Industrial and Corporate Change* 3.1, pp. 47–63. DOI: [10.1093/icc/3.1.47](https://doi.org/10.1093/icc/3.1.47).
- Nelson, Richard R. and Sidney G. Winter (1982). *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press. ISBN: 9780674272279.
- North, Douglass C. (1990). *Institutions, Institutional Change and Economic Performance*. Cambridge: Cambridge University Press.
- Nosek, Brian A., George Alter, George C. Banks, et al. (2015). "Promoting an Open Research Culture". In: *Science* 348.6242, pp. 1422–1425. DOI: [10.1126/science.aab2374](https://doi.org/10.1126/science.aab2374).
- Noy, Shakked and Whitney Zhang (2023). "Experimental Evidence on the Productivity Effects of Generative Artificial Intelligence". In: *Science* 381.6654, pp. 187–192. DOI: [10.1126/science.adh2586](https://doi.org/10.1126/science.adh2586).
- Ooijen, Charlotte van, Barbara Ubaldi, and Benjamin Welby (2019). *A Data-Driven Public Sector: Enabling the Strategic Use of Data for Productive, Inclusive and Trustworthy Governance*. Tech. rep. 33. Paris: OECD Publishing. DOI: [10.1787/09ab162c-en](https://doi.org/10.1787/09ab162c-en).
- Open Science Collaboration (2015). "Estimating the Reproducibility of Psychological Science". In: *Science* 349.6251, aac4716. DOI: [10.1126/science.aac4716](https://doi.org/10.1126/science.aac4716).
- Ostrom, Elinor (2010). "Beyond Markets and States: Polycentric Governance of Complex Economic Systems". In: *American Economic Review* 100.3, pp. 641–672. DOI: [10.1257/aer.100.3.641](https://doi.org/10.1257/aer.100.3.641).
- Pfeffer, Jeffrey and Gerald R. Salancik (1978). *The External Control of Organizations: A Resource Dependence Perspective*. New York: Harper & Row. ISBN: 0060451939.
- Plato (1921). *Theaetetus*. Trans. by Harold N. Fowler. Vol. 12. Cambridge, MA: Harvard University Press.
- Porter, Theodore M. (1995). *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*. Princeton, NJ: Princeton University Press.
- Powell, Walter W., Kenneth W. Koput, and Laurel Smith-Doerr (1996). "Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology". In: *Administrative Science Quarterly* 41.1, pp. 116–145. DOI: [10.2307/2393988](https://doi.org/10.2307/2393988).
- Reber, Rolf, Norbert Schwarz, and Piotr Winkielman (2004). "Processing Fluency and Aesthetic Pleasure: Is Beauty in the Perceiver's Processing Experience?" In: *Personality and Social Psychology Review* 8.4, pp. 364–382. DOI: [10.1207/S15327957PSPR0804_3](https://doi.org/10.1207/S15327957PSPR0804_3).
- Rochet, Jean-Charles and Jean Tirole (2003). "Platform Competition in Two-Sided Markets". In: *Journal of the European Economic Association* 1.4, pp. 990–1029. DOI: [10.1162/154247603322493212](https://doi.org/10.1162/154247603322493212).
- Schlager, Edella and Elinor Ostrom (1992). "Property-Rights Regimes and Natural Resources: A Conceptual Analysis". In: *Land Economics* 68.3, pp. 249–262. DOI: [10.2307/3146375](https://doi.org/10.2307/3146375).

- Schwartz, Joan M. and Terry Cook (2002). “Archives, Records, and Power: The Making of Modern Memory”. In: *Archival Science* 2.1–2, pp. 1–19. DOI: [10 . 1007 / BF02435628](https://doi.org/10.1007/BF02435628).
- Scott, John (1990). *A Matter of Record: Documentary Sources in Social Research*. Cambridge: Polity Press.
- Sen, Amartya (1999). *Development as Freedom*. Oxford: Oxford University Press.
- Simon, Herbert A. (1971). “Designing Organizations for an Information-Rich World”. In: *Computers, Communications, and the Public Interest*. Ed. by Martin Greenberger. Baltimore, MD: Johns Hopkins Press, pp. 37–72.
- Srnicek, Nick (2016). *Platform Capitalism*. Cambridge: Polity.
- Stanford Institute for Human-Centered Artificial Intelligence (2026). *AI Index Report 2026*. Stanford, CA: Stanford University. URL: <https://hai.stanford.edu/ai-index/2026-ai-index-report>.
- Trouillot, Michel-Rolph (1995). *Silencing the Past: Power and the Production of History*. Boston: Beacon Press.
- UNESCO (Nov. 23, 2021). *Recommendation on Open Science*. Paris: United Nations Educational, Scientific and Cultural Organization. URL: <https://www.unesco.org/en/legal-affairs/recommendation-open-science>.
- Veblen, Thorstein (1914). *The Instinct of Workmanship and the State of the Industrial Arts*. New York: The Macmillan Company.
- Wenger, Etienne (1998). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge: Cambridge University Press.
- Wilkinson, Mark D., Michel Dumontier, IJsbrand Jan Aalbersberg, et al. (2016). “The FAIR Guiding Principles for Scientific Data Management and Stewardship”. In: *Scientific Data* 3, p. 160018. DOI: [10 . 1038/sdata . 2016 . 18](https://doi.org/10.1038/sdata.2016.18).
- Winsberg, Eric (2010). *Science in the Age of Computer Simulation*. Chicago: University of Chicago Press.
- World Bank (2021). *World Development Report 2021: Data for Better Lives*. Washington, DC: World Bank. ISBN: 9781464816000. DOI: [10 . 1596/978 - 1 - 4648 - 1600 - 0](https://doi.org/10.1596/978-1-4648-1600-0).
- Young, Iris Marion (1990). *Justice and the Politics of Difference*. Princeton, NJ: Princeton University Press.