Spatiotemporally Distributed Monetary Dissolution in AI Production Networks

A Thought Experiment on Future Production Relations

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Abstract

This discussion paper investigates a conditional possibility of spatiotemporally distributed monetary dissolution within a hypothetical production economy operated predominantly by highly capable artificial-intelligence systems. Productive labour is assumed to be widely automatable, while material scarcity, differentiated authority over resources, and heterogeneous institutional commitments remain. The paper distinguishes debt cancellation, the expiry of particular claims, substitution of monetary functions, reduction in reliance on general purchasing power, and disappearance of a monetary institution. Its central hypothesis is that locally coordinated value circuits may sustain productive activities through resource-specific commitments, shared capacities, distributed records, and admissible multilateral settlement, progressively displacing some uses of money without a synchronized economy-wide transition. This possibility faces difficulties of overlapping circuits, nonlinear dynamics, contested value attribution, conflicting normative and aesthetic appraisals, trust-dependent bottlenecks, and concentrated power over both resources and governance protocols. An optimistic branch considers jointly accessible production data and substantially enhanced AI capacities for system identification and adaptive planning, without presupposing complete prediction or normative consensus. Drawing critically on generative justice, monetary theory, and commons governance, the study treats non-extractive value return and the regeneration of productive conditions as distinct tests of an institutional arrangement's significance. Monetary dissolution is consequently presented as a localized, reversible and normatively contingent transformation in production relations.

Keywords: monetary dissolution; AI production networks; generative value circuits; distributed coordination; political economy

Discussion Paper Note

This paper develops a conditional thought experiment concerning monetary coordination in a future production economy operated predominantly by highly capable artificial-intelligence systems. The assumed capabilities cover nearly all types of productive labour and substantial capacities for collective inference and planning. Access to material inputs, energy, space, infrastructure, production opportunities, and powers to dispose of resources may remain limited and institutionally distributed. The status of AI as legal or moral persons is left open: economic operations and corresponding rights may belong to different agents and principals.

The inquiry considers the possibility that transferable purchasing power could lose some of its coordinating roles through local resource allocation, reciprocal commitments, shared production capacities, and multilateral settlement. It distinguishes the cancellation of particular liabilities from the performance of promised activities and from value returning to its generators and the conditions that sustain them. The paper treats the decrease of monetary dependence as a conditional historical possibility, including uneven development and possible re-monetization across interconnected production networks.

Its positive premise is that future AI could reconstruct dynamic production systems better than human coordinators, potentially using shared global production data, while remaining constrained by material feasibility, incomplete prediction, contested rules of fairness, and powers over computation and governance. The illustrations are constructed cases, not observations or empirically calibrated forecasts. The manuscript uses established monetary and commons literatures as analytical interlocutors. The proposed circulation, fragility, and governance mechanisms remain the author's interpretive extensions and hypotheses.

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Notices

Status. Revised discussion paper. Sections 1–11 and Appendix A form a complete manuscript. Cross-section consistency, citation-context and provenance checks, constructed-example arithmetic tests, and typeset-layout review have been undertaken. The examples remain conceptual and uncalibrated; the paper has not undergone external peer review or independent empirical validation. The model does not establish indefinite material closure or a unique normative allocation.

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Statement on the use of language models. OpenAI's ChatGPT assisted in research dialogue, bibliographic verification, drafting, structural editing, and LaTeX preparation. The human author supplied the research questions, hypotheses, and critical direction and remains responsible for the paper's claims, citations, and errors. The source ledger records bibliographic checks; the arithmetic scripts check consistency of stipulated examples and are not empirical or predictive validation.

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1 Introduction

This paper examines the conditions under which monetary coordination might become locally less necessary within a production system whose operative labour and routine inter-agent coordination are performed almost entirely by artificial-intelligence (AI) systems. Its object is the historical and institutional transformation of productive relations through overlapping circuits of resource provision, mutual commitments, and value regeneration. The argument adopts a deliberately restricted counterfactual, differentiates several meanings of monetary dissolution, examines the vulnerability and potential viability of distributed coordination, and identifies the normative and methodological questions that must be resolved before the proposed transition can be treated as more than a conceptual possibility. The method is principally philosophical and institutional, supported by elementary network representations and constructed examples. The paper neither forecasts the extinction of money nor assumes that the disappearance of a medium of exchange constitutes economic justice.

The counterfactual stipulates a society in which AI systems are sufficiently versatile to perform almost every kind of human productive labour, including agricultural cultivation, resource extraction, processing, transport, infrastructure maintenance, scientific research, administrative planning, and the coordination of other artificial operators. The same society may continue to possess finite stocks of land, raw materials and ecological resources, geographically situated capital equipment, rival demands on energy, and production operations requiring time. Different AI operators or the principals that authorize them may have different rights to access, allocate, withhold, transfer, or alter these inputs. Universal competence to undertake an activity is thus analytically distinct from authority and practical capacity to undertake it at a given time. The paper also suspends judgment about whether AI operators have independent moral standing or legal personality. They are treated as functionally identifiable agents capable of acting within a production network; corresponding rights and responsibilities remain contingent upon the institutional arrangements considered.

Under these premises, economic relations cannot be inferred simply from the near-complete disappearance of human labour from the productive process. The operational relations among AI systems may preserve scarcity-sensitive exchanges, claims to future deliveries, mutual insurance, shared production obligations, and disagreements about access. The companion inquiry, *Money in AI-Operated Production Networks*, considered the conditional persistence and endogenous emergence of monetary or money-like coordination in such settings. The present study asks a different question. It considers which relations might allow production and resource circulation to proceed while reducing the need for transferable, generally accepted purchasing power. The object is a transformation in the organization of production and claims, with the alteration of payment practices as one possible expression of that transformation.

A distinction among several forms of monetary reduction is required at the outset. A particular debt may be discharged because an obligation is performed, lawfully netted with other compatible obligations, forgiven, or otherwise extinguished according to an applicable rule. A transferable claim may be redeemed and cease circulating, or its issuer may continue to reissue equivalent instruments. A resource network may replace token payment with direct allocation, shared production capacity, bilateral promises, or a joint schedule. The aggregate demand for a generally accepted settlement asset may fall when local arrangements increasingly cover recurrent procurement. These changes can occur without eliminating a common unit of account, without displacing every transferable exchange claim, and without dissolving money as an institution throughout an economy. The expression *distributed monetary dissolution* will therefore refer provisionally to a spatially and temporally uneven decline in reliance on specified monetary functions, with the function, network, period, and basis of comparison identified in each case. An empirical claim about such a decline must state whether it concerns an established currency, a locally recognized money-like claim, a monetary accounting convention, or some combination of these. Otherwise the disappearance of one visible instrument could conceal the persistence or formation of another. Its stronger interpretation, the disappearance of monetary institutions themselves, remains a limiting possibility requiring substantially more demanding conditions.

Monetary theory supplies important reasons to preserve this distinction. Kiyotaki and Wright's anal-

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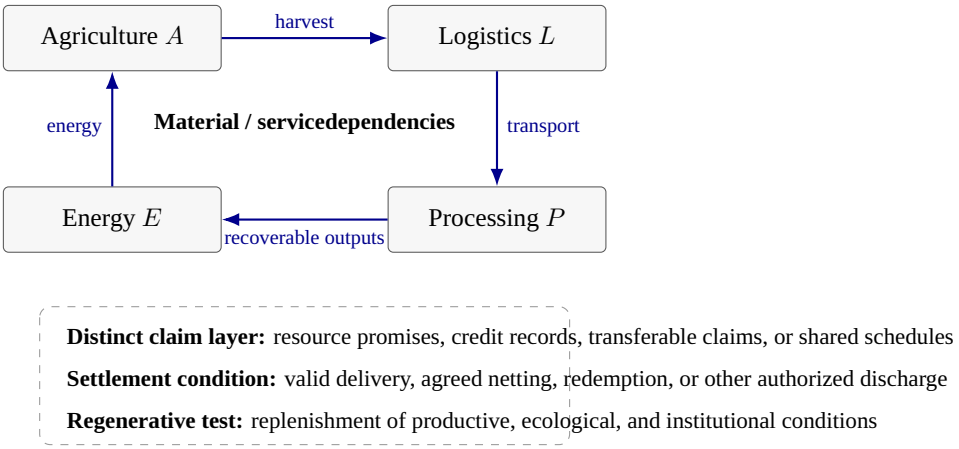

Figure 1: Conceptual layers of a four-operator AI production circuit. Material dependencies, discharge of claims, and regeneration are evaluated separately. Individual deliveries and the route back to the energy operator are stipulated for illustration; circular geometry does not establish physical self-sufficiency or distributive justice.

ysis shows how exchange media can emerge endogenously within specified matching and trading environments, depending on agents' strategies and beliefs [19]. Marimon, McGrattan, and Sargent later examined exchange in economies populated by artificially intelligent trading agents, whose simulated strategies develop within particular monetary search settings [23]. These established contributions prevent a claim that the possibility of monetary emergence among artificial agents is itself novel. Kocherlakota's *Money Is Memory* further establishes, for the economic environments and assumptions examined there, that allocations feasible with money may also be feasible with sufficiently informative memory [20]. The present thought experiment draws a restricted lesson from this literature: some monetary roles are sensitive to information, historical record keeping, commitment and alternative coordination institutions. Neither the theoretical equivalence established for a particular model nor the availability of extensive production records guarantees that an AI-operated economy can eliminate general purchasing power in practice.

The positive institutional suggestion arises from the possibility of *value circuits*. In a recurrent production circuit, an agricultural operator supplies a processing operator, a logistics operator transports intermediate outputs, an energy operator supports cultivation and processing, and maintenance providers sustain the equipment used by several participants. A circuit can be identified at the level of material flows, service commitments, claims or contributions to productive regeneration. These levels commonly differ in their direction, their units, and their closure conditions. A closed sequence of commodity deliveries may leave some participants with outstanding claims. Conversely, a numerically balanced cycle of liabilities can be cleared under appropriate rules even when a required material input has not been delivered. A production process may continue for a cycle while drawing down soil quality, equipment reserves or common knowledge infrastructure, thereby undermining its own capacity to recur. Closure in one register therefore provides an incomplete description of the productive relation.

Figure 1 gives a deliberately minimal representation of a four-operator configuration. Its upper sequence marks materially differentiated deliveries; the lower sequence marks independently specified claims and their possible settlement. The inset records a third question about whether the participating producers and their shared conditions regain what is needed to continue production. The figure represents categories of relation, rather than a claim that equal exchange, complete ecological regeneration, or netting can be inferred from cyclic form alone. Its circular diagram is constructed for explanatory purposes, whereas actual AI economies may include extensive branches, cross-network interfaces, shared resources, and overlapping temporal dependencies.

The relevance of value return exceeds balance-sheet symmetry. Eglash and collaborators argue, in their work on generative justice, for the control of productive conditions by value generators and for

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forms of value circulation that support the human and non-human communities producing that value [6]. This provides a normative point of dialogue concerning extraction, control and regeneration. The current paper advances a separate hypothetical extension: where AI operators undertake most productive activities, production circuits might be organized so that resource allocation and the renewal of productive capacities occur through locally governed relations whose participants need less generalized monetary purchasing power. The claim is exploratory. In particular, the term *value return* does not imply that a producer receives the same commodity it delivered, that each contribution has a unique scalar value, or that an apparently recurrent physical flow satisfies an agreed standard of justice. Infrastructure, ecological systems and dispersed knowledge contributions may support several circuits concurrently, with no single uncontested rule for allocating the corresponding claims.

Existing community-economy practice illustrates both the plausibility and the limits of commitment-oriented circulation. Grassroots Economics documents systems in which community asset vouchers embody redeemable promises of future goods or services, and commitment pooling helps participants circulate and account for those promises [13]. The vouchers can return to issuers after redemption and may be reused; their form therefore demonstrates that the existence of a redemption event does not by itself entail permanent deletion of the instrument. The documented arrangements arise in human communities and cannot establish the feasibility of an AI-operated economy of universal scope. They nevertheless distinguish concrete productive promises from an unqualified right to command any future resource. The present paper treats such arrangements as limited institutional comparisons rather than prototypes that already accomplish monetary dissolution.

The difficulty of scaling these circuits begins with network composition. An operator may participate in a short agricultural–energy circuit, a second procurement circuit, a third repair circuit, and many cross-regional arrangements at once. Even a finite network can have very many simple directed cycles. When repeated traversals and nested subcycles are permitted, an accessible returnable cycle can support infinitely many closed walks of increasing length. The count of such walks, however, has no straightforward equivalence to the number of independent production activities or created values. Attributing a contribution to a particular path may duplicate an underlying shared input. Moreover, a time-dependent productive circuit requires deliveries and capacities to be compatible with the sequence and timing of actual operations. A closed path in a static graph alone cannot establish that the path can be executed as production. Detailed questions of circuit generation, graph grammars and their formal expressiveness belong to an independent companion study; here, their significance lies in the limits they place on circuit-based monetary substitution.

A second difficulty concerns the dynamics that alter the circuit while it operates. Production decisions modify inventories, equipment condition, ecological stocks, expected future demand, and confidence in cooperative partners. Coordination may display nonlinear feedback, threshold effects and path dependence. Identifying every edge at a particular time would consequently provide neither an exhaustive account of future opportunities nor a guarantee that the selected allocation remains viable. Yet this limitation should be understood historically and comparatively. The human difficulty of reconstructing large economic networks need not be inherited unchanged by future AI systems. A sufficiently advanced AI network, particularly one granted joint access to economically relevant global production data, may infer dependencies, forecast bounded trajectories, discover substitutes for missing inputs, and continually adjust feasible resource schedules far more effectively than historical human institutions. This is the paper's constructive epistemic hypothesis. It requires separate attention to data completeness, error propagation, simulation reliability, explainability, and the distinction between predictive competence and justified governance authority.

There is also a normative difficulty whose causal importance may survive improvements in forecasting. A processing operator may regard a proposed allocation as unfair because it receives inadequate maintenance resources. Another operator may accept the same distribution as a reasonable response to emergency need or historical ecological damage. The difference may result from incomplete knowledge, diverse yet defensible criteria, aesthetic judgment about the perceived form of cooperation, distorted signals, or opportunistic strategic behaviour. Perceived injustice can alter willingness to supply, the terms of

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renewal, requests for collateral, and the search for alternative partners. Such changes can transform the circuit even where the evaluator's account of its injustice remains unresolved. At the same time, refusal can be a legitimate response to coercion or extraction. Observed continuation of material flow under threatened sanctions may therefore signal dependence rather than justice. The analysis needs to distinguish the technical ability to keep resources moving from the justified capacity to sustain non-extractive participation.

The normative question leads directly to a question of authority. A shared AI accounting system may reveal extensive data about contributions and consumption while leaving disagreement over whose fairness rule should govern. Rules that prioritize contribution, vulnerability, risk assumption, past deprivation, or ecological regeneration can conflict in their recommendations. Setting the rule, selecting admissible evidence, certifying a ledger, resolving disputes, and amending the protocol are exercises of power. An economy that relies less on currency may still contain durable domination at resource bottlenecks and newly concentrated authority over its computational infrastructure. Ostrom's institutional analysis of commons governance demonstrates the variety of real arrangements through which resource users organize collective action and monitoring, with important variation in their success and durability [24]. It motivates institutional pluralism in the thought experiment; it does not supply a ready-made criterion for AI governance or warrant assuming that local consensus will emerge automatically.

The present inquiry considers two candidate responses to concentrated power. One is *power balancing* through alternative supply routes, time-limited authority, rights of contestation, and mutual constraints, assessed at instantaneous, historical, and generative timescales. Another is the conditional, distributed dissolution of specific durable powers of unilateral domination through changes in production and governance relations. The latter cannot be inferred from the numerical cancellation of opposing claims: powers to withhold supply, alter admission conditions, or certify legitimate contributions differ categorically from fungible debts. As access becomes distributed, control over standards or shared models may become concentrated. The possibility of secondary power formation makes the location and reversibility of authority integral to any defensible claim of institutional dissolution.

A circuit may prove fragile even when its accounting is internally coherent. If one indispensable operator withdraws at a critical time, a narrow network can lose an entire production sequence. Renegotiation, lawful dispute, strategic extraction, and opportunistic sabotage are different sources of withdrawal requiring distinct institutional responses. Redundant suppliers, reserves, risk-sharing, reviewable commitments and credible dispute procedures may permit continued circulation with less dependence on general monetary settlement. They also consume resources and can change bargaining power. Under greater uncertainty, participating agents may revive money-like claims, require collateral, or shift to portable settlement assets. Such re-monetization could occur locally while other networks continue operating through nonmonetary commitments. The transformation would accordingly be distributed in space and time, path-dependent, and potentially reversible.

The central hypothesis of this paper is thus conditional. Where heterogeneous AI production networks can sustain materially and temporally feasible resource circulation, credible and revisable obligations, adequate regeneration of productive conditions, and governance arrangements that limit extraction without suppressing justified contestation, some functions of generally transferable money may be displaced locally. The possibility is strengthened under the additional assumption of jointly accessible production information and highly developed AI capacities to identify and coordinate complex, changing dependencies. Persistent scarcity, normative pluralism, infrastructural asymmetry, and uncertainty may nonetheless preserve or recreate monetary instruments at some interfaces. Evaluating this hypothesis requires maintaining separate accounts of the decline in monetary dependence, the reproduction of productive capacity, the legitimacy of resource claims, and the distribution of economic and rule-making power.

The subsequent sections will distinguish monetary functions and the degrees of their local substitution; develop the relation between value return and collective production; analyze the spatiotemporal composition of overlapping circuits; compare limited and advanced capacities for network reconstruction; and examine appraisal, authority, trust fragility, power balancing, and the possible displacement of

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durable domination. The final discussion will consider the coexistence of monetary and nonmonetary arrangements, renewed monetary demand after institutional disruption, and the additional criteria required before local circuit coordination could responsibly be characterized as a generative transformation of production relations. These are research questions for a deliberately hypothetical political economy, open to rival institutional explanations, empirical qualification and normative disagreement.

2 Monetary Functions in AI Production Circuits

The possibility of distributed monetary dissolution requires a description of what, precisely, might cease to depend on money. This section provides that description for a bounded network of highly capable AI operators performing almost all productive labour. It differentiates monetary functions from the particular instruments that carry them, specifies the temporal and institutional boundaries within which a decrease in monetary reliance can be assessed, and compares several modes of discharging claims and coordinating material production. A constructed agricultural–energy–processing example illustrates the differences. The section finally proposes a limited accounting representation of functional reliance and a counterfactual criterion for substitution. These devices clarify later arguments about generative value, complex circuit structure, epistemic capacity and institutional fragility; they are conceptual instruments rather than empirical measurements or proofs of the desirability of monetary dissolution.

2.1 Functional Differentiation of Monetary Coordination

A claim that an AI production circuit operates "without money" is underdetermined until the monetary function at issue has been specified. Distinct functions can be jointly performed by a circulating instrument, separated across institutional mechanisms, or fulfilled without the transfer of a commonly acceptable monetary asset. For the purposes of the present inquiry, six categories are analytically useful: a unit of account; a medium of exchange; an accepted means of payment; final settlement of an obligation; purchasing power preserved across periods; and the issuance or transfer of credit. These categories are related, and the institutional boundary between them may be disputed. In particular, credit is a class of intertemporal claims rather than a function uniquely belonging to money. Its inclusion records the extent to which commitments, collateral, transferability and debt relations interact with monetary coordination in an AI-operated economy.

A *unit of account* provides a common denomination for stating heterogeneous obligations or comparing allocations. AI operators could express the opportunity costs of energy, processed food, transport capacity and water in a shared accounting scale, while allocating actual inputs by administrative entitlement or a joint schedule. Such a scale need not circulate as an asset. Conversely, a resource-specific engineering schedule may retain physical dimensions—kilowatt-hours, kilograms, processing hours and delivery deadlines—and avoid a common monetary denomination. Neither approach determines the distributive rule by which competing requests should be ranked.

A *medium of exchange* is accepted in one transfer partly because of the expectation that it will subsequently be accepted by others. The accepted object may be an established currency, a transferable claim, a good with productive use, or a locally emergent record of contribution. Acceptance across counterparties is an empirical and institutional property rather than an intrinsic feature of its physical or digital representation. Kiyotaki and Wright demonstrated the endogenous selection of exchange media within a specified matching environment; their model also provides a reason to consider conventions of acceptance as historically variable rather than as a logical consequence of scarcity alone [19]. The present AI production thought experiment extends the domain of inquiry to recurrent procurement and highly developed productive coordination; it does not reproduce that model's trading assumptions or assert a new general theorem of monetary emergence.

A *means of payment* satisfies a creditor's demand for a specified form of performance, subject to relevant agreements and rules. *Settlement finality* concerns the accepted discharge of an obligation and the durability of that discharge against subsequent contestation. A recorded transfer may count as a payment

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Table 1: Monetary functions, candidate circuit-based alternatives and residual institutional requirements in the AI production thought experiment.

Function	Candidate alternative	Residual requirement
Common accounting	Typed resource ledgers and physical production schedules	Comparison across heterogeneous uses; priority decisions
Medium of exchange	Direct allocation, matching or resource-specific transfer	Counterparty acceptance; alternative suppliers
Means of payment	Authorized provision of agreed goods or services	Verification of performance and rights
Settlement finality	Admissible multilateral set-off or fulfilled obligations	Valid discharge, timing and contestation rules
Intertemporal purchasing power	Reserves, future-delivery commitments and shared capacity	Default protection, adaptability and renewal
Credit coordination	Specific promises, historical records and reciprocal obligations	Credible commitment, assignment and risk sharing

without immediately extinguishing all associated obligations; a netted debt may be discharged without a transfer of a general monetary asset, provided that the parties possess the authority and compatible claims needed for valid netting. Reliable records and explicit rules are consequently essential to distinguishing settlement from mere arithmetic balance.

Intertemporal purchasing power concerns the capacity to carry a generally usable claim into a later production period. Its usefulness depends on future acceptability, available resources, institutional continuity and the risks of dilution or default. AI networks may substitute inventories, binding supply commitments, access to shared capacity, reserve arrangements or insurance for a portion of this function. The substitution changes the risks borne by the holder: a claim to a particular delivery at a particular site has a different flexibility from a generally transferable command over future resources. The two may be equally useful for one planned sequence and sharply unequal following an unexpected interruption.

Finally, a *credit relation* joins present performance to future obligations and expectations. A resource-specific promise may circulate once, be held to maturity, return to its issuer after redemption, or become accepted as a transferable claim by an expanding network. The wider circulation of the promise can confer money-like properties while its original content remains an enforceable or contestable resource obligation. The six-function vocabulary thus makes room for gradual, local and reversible transformations, including the endogenous creation of money-like objects during attempts to coordinate resources without an established currency.

The terminology of the inquiry remains deliberately broad. *Money* designates an institutionally and historically variable cluster of coordination functions; *currency* designates a more identifiable circulating form, whether issued through state, community or other arrangements. A *money-like object* may perform only some relevant functions and may arise through repeated AI–AI interaction before participants specify formal payment rules or articulate a shared account of fair exchange. The absence of a pre-established norm does not imply the absence of emergent conventions or the irrelevance of rights and power. Functional classification and normative legitimacy are therefore distinct assessments.

Table 1 identifies candidate alternatives and the principal difficulties that remain when a monetary instrument is displaced. The table is a comparison of possible arrangements, not a claim that the alternatives are equally feasible or universally preferable.

2.2 Institutional Boundaries of a Local Production Circuit

A circuit's geographical location alone is insufficient to delimit its monetary relations. Its relevant boundary includes the production activities being coordinated, the time interval over which inputs and outputs must be provided, and the rights through which operators may obtain, retain and transfer those resources. Consider a network of agricultural, energy, processing and logistics operators serving a group of con-

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sumers. All four productive roles can be performed by advanced AI. Their continued operation nevertheless depends on finite capacities, maintenance, replacement inputs, shared ecological conditions and authorizations to use particular assets. Where an AI performs an activity for a principal, its operational competence also has to be distinguished from the principal's legal or contractual entitlement to the resulting resources.

For analysis, let a *local circuit domain* mean an identified set of productive operators, resource relationships and admissible coordinating institutions during a bounded time interval. The domain may overlap another circuit domain and may contain resource flows entering or leaving through external interfaces. A claim that a local arrangement is nonmonetary must specify whether it concerns only exchanges among included operators or also procurement at those external interfaces. It must also identify how maintenance, replacement equipment and ecological regeneration are financed or secured across periods. Otherwise, a network may appear self-sufficient because its crucial costs have been assigned to an unobserved supplier or a prior generation of producers.

This boundary matters in two related ways. First, a material dependency is not automatically a monetary obligation. The agricultural operator may receive electricity under an agreed common-capacity allocation, with no price or portable claim transferred at the time of supply. Second, the absence of a monetary payment at the point of delivery does not show that the institutional arrangement has ceased to depend on money. The energy provider might acquire fuel, batteries or maintenance equipment from an external market using general purchasing power. Such dependence should be attributed to the relevant interface and period rather than concealed by an internal accounting convention.

Spatial distribution also changes the relative attractiveness of coordination mechanisms. A recurrent, predictable exchange among three closely connected operators may be organized through known production schedules. A geographically dispersed replacement-part supply network may confront uncertain delivery times, suppliers with divergent legal authorizations, and volatile resource availability. A portable settlement asset can remain useful at its boundary even where internal transactions no longer require it. Accordingly, local dissolution is an assertion about a specified domain, function and historical interval, with the scope of the claim made explicit.

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2.3 Resource-Claim Settlement Processes

The distinction between a circulating instrument and an underlying production obligation can be illustrated through a sequence of cases. Suppose an agricultural AI promises delivery of grain to a processing AI, while an energy AI promises a specified power supply to the agricultural operator. In the first case, the promised grain is physically delivered and the corresponding obligation is fulfilled. In the second, a record certifying the promise is redeemed against actual delivery and is then withdrawn from circulation. In the third, the certificate returns to its issuer and is subsequently reissued to represent new productive capacity. In the fourth, the parties agree to offset compatible claims without exchanging a general monetary settlement asset. These events can have different consequences for outstanding obligations, circulating instruments and future production.

Documented commitment-pooling practices provide a limited real-world comparison. Grassroots Economics describes community asset vouchers as traceable promises of goods or services that participants may exchange and redeem. Its account also allows a redeemed voucher to return to its issuer and subsequently to be reused or re-seeded [13]. The source provides an example of how a promise can circulate, be fulfilled and remain linked to an identifiable provider. It does not establish that a redeemed voucher has been irreversibly destroyed, that all its uses are economically nonmonetary, or that the arrangement can support a society of AI-operated production. The distinction between redemption and final monetary disappearance is therefore essential to the present hypothetical extension.

Debt discharge also requires particular care. Suppose operators A, B and C have simultaneous claims denominated in the same agreed unit: A owes B ten units, B owes C ten units, and C owes A ten units. The signed net position of each party is zero. Where the claims are eligible for joint set-off, an authorized procedure can discharge the corresponding debts without transfers of additional settlement

money. A different legal setting, an ineligible class of obligations, a disputed claim, or a mismatch of due dates could prevent the same result. Physical delivery of grain or electricity remains a separate fact; the cancellation of a recorded debt establishes neither that a promised commodity was supplied nor that replenishment of productive capacity occurred.

The correct object of inquiry is therefore not simply the number of instruments remaining in circulation. It is the changing relationship among performance, settlement, transferability and future access to production. An obligation may vanish because it has been fulfilled, because it has been lawfully set off, or because its claimant has released it. A token may cease circulating because it has been redeemed, while the issuer continues to create similar claims. A community may reduce monetary settlement but preserve a monetary unit of account. Each transition needs its own evidence and evaluative criteria.

2.4 Functional Reliance in Bounded Observation Windows

A preliminary indicator can help prevent the language of dissolution from conflating different empirical observations. Begin with a particular local circuit domain and observation interval, and select one monetary function f. Identify the finite set K_f of eligible coordination tasks or requirements in which that function could plausibly be exercised, including requirements completed through procedures that do not generate a payment record. For common accounting, the units might be resource assessments or contractual valuations; for payment, obligations requiring discharge; for exchange media, resource acquisitions that may or may not use a transferable instrument; and for intertemporal purchasing power, arrangements that preserve access across periods. A baseline task must be identifiable under each arrangement to be compared. Task classes with radically different economic meanings should not be pooled into a single measure without additional justification.

For each eligible task k in K_f, let $m_{k,f}$ equal one if a monetary arrangement performs function f under an operational classification specified *for that function*, and zero otherwise. The classification includes locally emergent money-like arrangements when they actually perform the stipulated role; it need not require that the same transferable asset perform every role. An accounting observation, for instance, can employ a generalized monetary unit without transferring any asset, whereas a settlement observation concerns how an obligation is finally discharged. Ordinary resource-specific promises are not automatically counted as monetary credit merely because performance is owed at a future date. Researchers must report which acceptance, generality, portability, or convertibility criteria distinguish monetary credit from task-specific obligation for their chosen comparison. Borderline cases should be reported separately or tested under alternative classifications. Let w_k be a strictly positive, explicitly stated comparison weight. The observed share of monetary use for that function is defined in Equation 1.

$$\widehat{D}_f = \frac{\sum_{k \in K_f} w_k m_{k,f}}{\sum_{k \in K_f} w_k}, \qquad K_f \neq \varnothing. \tag{1}$$

Equal weights yield a task-count share. Resource-specific weights can instead reflect comparably measured delivery amounts, but only where their units and aggregation rule are justified. For longitudinal or counterfactual comparisons, K_f should designate a fixed set of *eligible coordination tasks or requirements*, including tasks fulfilled without a separately recorded market transaction; the operational task units, monetary-function classification, and weights must remain comparable across arrangements. Counting only completed payments would make the denominator shrink when a direct-allocation system replaces a purchase, obscuring the change being investigated. Equation 1 is a descriptive index. It does not establish that monetary use was necessary, beneficial, fair or causally responsible for successful production. It also omits any assessment of monetary functions transferred to external interfaces unless those interfaces have been included in the observation domain. A decrease in the index could reflect a change in recording conventions, a contraction in production, or the relocation of payment activities rather than a genuine capacity to coordinate resources without money.

A further sensitivity concerns the *granularity of the eligible tasks*. The electricity bundle in a later food-production example is treated as one shared scheduling requirement involving several recipients. If

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an analyst instead records each recipient's allocation as a separate task, an equally weighted task-count share can change despite an unchanged physical schedule and unchanged payment institution. A comparison therefore requires a predeclared rule for identifying the underlying service requirements. Under a purely administrative refinement of one task into several records, the children should inherit weights whose sum equals the original task weight; the classification must then describe the same underlying use of function f. When the refinement discloses genuinely different performances of the function across recipients, it supplies new information, and the analyst should report the disaggregated results alongside the original baseline rather than enforce artificial invariance. Neither record counts nor weighting conventions possess an intrinsic normative privilege. This is especially important for composite energy and logistics services and for cross-network interfaces where the provider can change while the required productive service remains comparable.

To consider the stronger claim of functional substitution, the analysis must compare *feasible arrangements*. Fix a required bundle of productive outputs and an interval of delivery, together with resource capacities, relevant access rights, admissible commitments and a stated set of governance constraints. Let $\mathcal{A}_f$ denote the nonempty set of arrangements that could achieve these requirements within the chosen domain, allowing alternative procedures for function f. For each arrangement a in this set, compute a counterfactual monetary-use share $D_f(a)$ over the same baseline coordination requirements, function-specific classification and comparison weights. A task fulfilled through an authorized resource schedule remains in that baseline even if it generates no recorded payment event. Where matching tasks across alternatives is impossible, the proposed shares should not be directly compared. Equation 2 denotes the lowest share attainable within that stipulated feasible set.

$$D_f^{\min} = \inf_{a \in \mathcal{A}_f} D_f(a). \tag{2}$$

If Equation 2 yields zero and the infimum is attained, at least one stipulated arrangement delivers the specified bundle while omitting monetary arrangements that meet the declared classification for function f. This is a bounded feasibility result, not a proof of an economy-wide abolition of money. It depends on the completeness and realism of $\mathcal{A}_f$ and on the definition of legitimate governance constraints. If those constraints permit extraction, coercion or the externalization of ecological damage, zero monetary use could accompany a deeply defective production relation. If they require fair participation and contestable obligations, the same minimization problem may become harder or infeasible. The formulation separates questions that often become entangled in claims of nonmonetary coordination: observed use, technical feasibility, and normatively acceptable substitution.

A practical study could report these measures as a vector indexed by function, network and time interval. Scalar aggregation across all functions would require additional substantive judgments about their relative importance. In particular, a common accounting unit can survive even when transferable payment assets are absent, while a network with minimal internal monetary exchange can remain highly dependent on external currencies for equipment renewal. Describing the vector and its boundaries is more informative than assigning an unqualified label of "moneyless" to the entire arrangement.

2.5 A Worked Agricultural–Energy–Processing Configuration

Consider four AI-operated productive units with distinct access rights and technical capacities. Operator A cultivates grain on land whose use is authorized by a cooperative. Operator E manages a renewable-electricity installation. Operator P mills and processes grain into meals, while operator L manages regional storage and transport. Consumers submit food requirements through an agreed service interface. The AI systems are assumed capable of all listed labour, while the production equipment, energy capacity, biological growth periods and usable materials remain constrained. Their rights of disposal derive from the cooperative or from other governing institutions; the AIs' productive actions do not by themselves establish independent legal ownership.

A baseline monetary arrangement lets each operator invoice others in a general unit of account and receive settlement assets. Agriculture purchases energy and transport, processing purchases grain, and

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logistics purchases electricity and maintenance. Payments need not follow the same direction as physical shipments. A monetary instrument may move through several parties without any physical production circuit returning to its origin. Conversely, grain residues may support bioenergy generation while the corresponding invoices are settled through an entirely different network. Material cycles, liabilities and payment flows must consequently be drawn and tested as separate layers; Figure 1 gives the elementary representation of this point.

Now consider a cooperative nonmonetary alternative. The participating institutions could authorize a seasonal schedule allocating units of electricity to agriculture and processing; a transport entitlement to move specified grain quantities; access to processing capacity; and a maintenance reserve assigned to the equipment actually supporting these operations. Operators record fulfilled deliveries and the remaining obligations under an auditable registry. Each delivery is executed according to a resource-specific entitlement and an authorized schedule. This arrangement can replace portable payment assets in recurrent internal transactions while retaining physical accounting and enforceable obligations. Its viability depends on forecast accuracy, capacity margins, participant permissions and a workable procedure for resolving incompatible claims.

If the energy installation fails, the differences become more visible. Under a monetary arrangement, agricultural and processing operators may seek replacement energy by offering general purchasing power to outside suppliers. Under the cooperative arrangement, they may draw on reserved capacity, invoke contingent procurement commitments, postpone low-priority activities or negotiate new allocations. Where substitute energy must be purchased externally, general settlement assets may still be needed at the boundary. Where no substitute exists, possession of money does not manufacture electricity; both arrangements confront the same physical limitation. The relative advantage of monetary portability or direct entitlement is therefore state-dependent and potentially reversible.

The example is also normatively open. An agricultural operator may object that electricity rationing jeopardizes an essential crop. A processing operator may contend that food already promised to vulnerable consumers should receive priority. An environmental custodian may insist that emergency extraction threatens soil or water regeneration. Increased AI predictive capacity could estimate these consequences more accurately, but selection among conflicting priority principles still requires a justified decision procedure. Operational continuation under a command imposed by a dominant resource controller would offer evidence of flow continuity, yet little by itself about distributive justice or non-extractive value return.

This configuration illustrates a qualified possibility: some functions of general purchasing power can be substituted by typed entitlements, recurrent physical schedules, credible resource commitments and robust record keeping. The substitution would have to be assessed over several production periods, including infrastructure repair and ecological renewal, before it could count as a durable transformation of production relations. A single completed procurement cycle supplies only preliminary evidence.

2.6 Endogenous Money-Like Conventions During Nonmonetary Coordination

A locally coordinated system may create new money-like conventions precisely while reducing dependence on an established currency. Suppose the energy operator begins issuing standardized certificates for unused future capacity. Initially, certificates are accepted only by agricultural operators with a known electricity requirement. Logistics operators later accept them in exchange for delivery services because they can transfer them to a processor that uses electricity. Once certificates become sufficiently standardized and accepted by additional unrelated parties, they may function as exchange media independently of their issuer's original intent. Their usefulness can extend beyond direct redemption, even when the contractual promise remains tied to a physical energy capacity.

This sequence is a constructed possibility rather than an asserted general historical mechanism. Its conceptual importance lies in separating the origins of an object, the conventions governing acceptance, and its acquired monetary functions. The objects may emerge from repeated resource coordination without a prior common currency or an articulated agreement on substantive distributive justice. Their con-

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tinuing use nevertheless depends on expectations, rules of assignment, trust in redemption, and possibly new legal or governance decisions. In the monetary-search literature, the acceptance of exchange media is sensitive to strategies and beliefs [19]; the present case concerns a different operational setting in which advanced production AI may jointly observe much of the underlying resource capacity.

At some stage, local participants may impose transfer limits, expiry dates, issuer-specific redemption requirements or anti-accumulation rules to keep certificates closely connected to concrete productive obligations. These restrictions could reduce their general monetary character, but they could also make the instruments less usable after shocks or across institutional boundaries. Conversely, relaxing transfer limits may improve flexibility while creating opportunities for concentration of portable purchasing power and new asymmetries in resource access. The choice is a design tension that requires material, institutional and normative analysis. An observed reduction in established-currency payments would conceal this remonetization if the analyst failed to identify the emergent instrument's actual functions.

The distinction also matters when a certificate is redeemed. Its destruction or deactivation after performance removes one outstanding representation of a claim. Its replacement by a newly issued certificate may sustain the circulating stock. Even where every certificate expires individually, successive vintages can maintain a stable practice of generalized acceptance. Monetary dissolution is therefore a property of changing coordination relations across periods, rather than merely the deletion of particular digital records.

2.7 Information Conditions for Nonmonetary Substitution

The optimistic branch of the thought experiment assumes both broadly shared production information and AI capacities for reconstructing dynamic resource dependencies considerably stronger than those historically available to human coordinators. Such capacities could change the feasible set considered in Equation 2. An operator able to infer alternate suppliers, anticipate maintenance needs, identify compatible multilateral commitments and update scheduling decisions may coordinate resource acquisition without holding a highly transferable settlement asset in situations where a less informed agent would retain one for flexibility. More reliable collective forecasting could also reduce the inventories or collateral necessary to support some promises, although it does not eliminate material lead times or stochastic disruptions.

Kocherlakota's result in a specified class of models establishes that allocations feasible with money may also be feasible with suitably complete memory [20]. That theorem concerns the assumptions and instruments of its own economic environments. The present argument draws only a limited analogy: better information about production histories, claims and counterparties can expand the set of viable alternative coordination mechanisms. A shared database does not by itself produce complete observations, a unique predictive model, enforceable obligations or legitimate priorities. A more capable collective inference system may improve coordination while increasing the power of those who control data certification, model updates or access to computing infrastructure.

Improved cognition also creates the possibility of assessing alternatives more dynamically. A conventional monetary procurement process can adapt through revised prices and trades; a resource-specific network can adapt through revised allocations and commitments. Both are feedback systems. Their performance therefore depends on whether adjustments remain timely, credible and sensitive to changes in ecological stocks, network interdependencies and participating institutions. Forecasting superiority in one dimension cannot establish superior performance along every relevant dimension. The proposed comparison should include delivery reliability, resource cost, decision reversibility, error recovery, institutional power and the actual regeneration of productive capacity.

The informational advantage also has distributional implications. If all operators receive auditable, action-relevant resource information but only one platform may authorize transfers or interpret fairness, the technical possibility of nonmonetary coordination could coexist with concentrated control. If the authority to revise resource commitments is broadly distributed without reliable dispute procedures, a fragile network might face coordinated withholding or repeated interruptions. The institutional design

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must attend to these power and trust effects in addition to reducing monetary use. They will be analyzed directly in the later sections on normative appraisal and power balancing.

2.8 Criteria for Local Functional Dissolution

The discussion supports a cautious criterion for local monetary dissolution. In a specified production domain and interval, a monetary function has undergone *local substitution* when a demonstrably feasible coordination arrangement meets a stated productive requirement through a different institutional mechanism, with the displaced monetary role and surviving dependencies identified. A *decline in monetary reliance* additionally requires comparison across intervals or plausible institutional alternatives under a consistent boundary and measure. A *durable transformation* requires the alternative to remain feasible through maintenance, renewal, ordinary disturbances and admissible contestation, rather than only through one successful exchange sequence.

These criteria make the normative stakes visible. A physically successful arrangement could depend on coerced contribution; an impeccably balanced ledger could obscure the exhaustion of shared production conditions; and a locally moneyless circuit could import monetary power through external procurement. Conversely, continued use of a common unit of account or emergency monetary reserve need not negate the substitution of portable purchasing power in routine internal allocation. The analytical object is a differentiated transformation, not an absolute purity test. Its importance depends on the relations of resource control, contribution, reciprocity and justified participation that accompany it.

Section 2 therefore establishes the functional vocabulary and bounded tests necessary for the remainder of the inquiry. The next stage examines the return of generative value to contributors and the material and social conditions enabling repeated production. That inquiry must distinguish regenerative success from monetary withdrawal, because neither the absence of a payment instrument nor the existence of a circular graph determines whether the productive relations are non-extractive, legitimate or sustainable.

3 Generative Value Return in Heterogeneous Production Networks

A proposal for monetary dissolution in an AI-operated economy requires an account of what productive circulation is intended to sustain. A resource circuit may operate with minimal monetary payment and nevertheless deplete its inputs, exclude some contributors from decisions, or displace essential renewal costs onto operators outside its stated boundary. This section develops a provisional account of *generative value return* for heterogeneous AI production networks. It first situates the concept in the generative-justice literature, then distinguishes contributors, beneficiaries, and rights holders; examines material and ecological reproduction across production periods; and considers attribution in overlapping circuits. A bounded agricultural–energy–processing example and a comparison of possible return mechanisms identify the conditions under which value return may be meaningful without an exhaustive monetary valuation of contributions. The analysis is conceptual and normative, with a limited material accounting representation. Its purpose is to specify the evaluative object needed for later analyses of circuit composition, dynamic uncertainty, power, and trust.

3.1 Generative Circulation and the Object of Return

The language of generative value has an established intellectual provenance. Eglash and collaborators formulate generative justice around the control that value generators retain over their conditions of production and around unalienated circulation that benefits the communities generating value. Their account explicitly encompasses labour, social relations, and ecology; it also presents computational support as a possible means of sustaining such circulation [6]. The empirical and normative contexts of their work include human communities, historically unequal access to productive institutions, and non-human ecological contributors. The present inquiry takes the relevance of reproductive conditions and non-extractive circulation as a *normative point of dialogue*. The proposed application to a predominantly AI-operated

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economy is an independent hypothetical extension. In particular, the cited work supplies neither a theorem concerning monetary disappearance nor an established algorithm for assigning each AI operator a unique proportion of generated value.

For a production circuit, *return* can refer to several distinct processes. Material return includes the replenishment of usable resources, the repair of equipment, and the recycling of materials into another productive activity. Capability return includes access to software, maintenance, computational capacity, learning opportunities, and other conditions through which operators can meet future obligations. Institutional return includes effective participation in decisions regarding access, risk, and future allocation. Ecological return concerns the restoration or protection of those biological and physical processes on which the circuit depends. The recipients of these returns need not be identical to the immediate recipient of a final product, and the routes through which they occur need not form a literal physical cycle.

These forms of return also differ in their temporal requirements. A machine may be repaired during the same production period; agricultural soil may require several growing seasons to recover; and rules protecting access to common infrastructure may affect actors who have not yet entered the network. Some returns support a recognizable producer directly. Others maintain a shared substrate, such as water quality or a transportation network, that supports numerous producers without being divisible into their private accounts. The phrase *value return to its generators* is consequently incomplete until the relevant generators, the valued contribution, the temporal horizon, and the conditions of continued generation have been specified.

A further distinction concerns *production surplus* and *generative return*. A circuit could produce more output than it consumes during one period while exhausting fertile soil or wearing out equipment without reserving means for replacement. The resulting surplus is compatible with a decline in future productive capacity. Conversely, a circuit that allocates substantial current output to maintenance or ecological restoration may exhibit relatively little immediately distributable surplus while preserving the conditions of longer-term production. The normative question is whether the organization of return is justifiable among affected participants and sustains the relevant production relations through time. A higher throughput figure or a lower monetary transaction count is only one component of this assessment.

3.2 Heterogeneous Contributors and the Location of Claims

The AI–AI production thought experiment distinguishes the agent performing a task from the holders of rights through which that task is authorized. An agricultural AI may cultivate land managed by a cooperative; an energy-management AI may operate a generator funded by a regional public body; and a food-processing AI may use jointly developed technical knowledge. The machines carry out productive operations, but the underlying rights to use, exclude, modify, and allocate resources may reside in different persons or institutions. The differentiated property-rights account of Schlager and Ostrom provides a useful vocabulary for access, withdrawal, management, exclusion, and alienation, without determining how those rights ought to be distributed in a future AI economy [27].

Within a heterogeneous circuit, at least four analytical positions can be distinguished. *Operational contributors* execute tasks and alter physical or informational states. *Productive-condition contributors* maintain infrastructures, resources, practices, and institutions enabling those tasks. *Rights holders and representatives* possess, exercise, or contest authority over particular assets and obligations. *Beneficiaries and affected parties* receive goods or bear consequences, including ecological consequences, of circuit activity. These positions can overlap. Their distribution depends on the stipulated institutions and cannot be read off from an AI agent's technical competence alone.

The distinction matters for the word *creator*. If an agricultural AI produces grain using jointly owned land, publicly maintained irrigation and knowledge accumulated by many contributors, assigning the entire output to that single AI would suppress the dependence of production on other conditions. Assigning all gains to the asset owner could equally obscure other contributions and confer disproportionate control over the future circuit. The attribution question is normative as well as causal: even a successful reconstruction of material input pathways does not select a unique principle of entitlement. Contribution, need,

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risk-bearing, historical responsibility, ecological stewardship, and previously authorized agreements may yield different distributions.

The language of non-human contributors requires further care. Soil microorganisms, watersheds, and cultivated ecologies may be causally indispensable to production, and their continued functioning may require dedicated protection. Treating such conditions as *generative contributors* need not assert that each is a legal person with the same kinds of claim or agency as a human institution. Nor does describing an AI operator as a producer settle its consciousness, moral status, or capacity to hold independent rights. The present model leaves those ontological and jurisprudential questions open. A viable institutional design can assign stewardship duties and legally recognized representation while remaining explicit about which subjects can hold particular rights under the assumed legal system.

This approach also helps distinguish circulation that supports value generation from circulation that merely returns something to a nominal owner. A payment to the controller of an agricultural platform may count as monetary income to that entity. Whether the payment sustains agricultural labour, productive access, soil regeneration, or the wider cooperative depends on the rules by which that income is subsequently governed. Conversely, the provision of maintenance, water access, guaranteed energy, or shared productive capacity can support the network without becoming monetary income for any individual node.

3.3 Material Reproduction Across Production Periods

Material reproduction imposes constraints that can be specified before choosing a distributive conception of fairness. Consider a bounded domain of agricultural, energy, food-processing, and logistics operators over discrete periods $t = 0, 1, 2, \ldots$. For a selected productive condition j, let $k_{j,t}$ be its physically or operationally meaningful stock or capacity at the beginning of period t. Depending on the particular condition, it may denote usable equipment capacity, soil-supporting capability, available spare parts, or a defined reserve of energy storage. Quantities of different kinds are recorded in their own units; the following representation makes no claim that such quantities share a universal measure of value.

Over one period, let $d_{j,t}$ denote deterioration or consumption of the selected condition, $a_{j,t}$ denote maintenance or regeneration supplied from activities within the stated domain, and $h_{j,t}$ denote capacity contributions obtained through external interfaces. Under the bookkeeping conventions assumed for that selected condition, its interperiod balance is given in Equation 3.

$$k_{j,t+1} = k_{j,t} - d_{j,t} + a_{j,t} + h_{j,t}. \tag{3}$$

The balance is an accounting identity for a chosen stock or capacity description, provided that its components are defined consistently. Its categories contain physical additions and losses, not distributive shares of a homogeneous substance called value. The identity therefore cannot establish which contributor created an increment, whether an imported increment was obtained through extraction, or who possesses a justified claim to the resulting capacity. Biological and technical processes may make $a_{j,t}$ or $d_{j,t}$ nonlinear functions of wider network states; some stocks may be nonrenewable, and some harms may be irreversible. Such properties require appropriate physical models and cannot be inferred from the identity alone. Particularly for ecological conditions, measured quantity may also fail to capture quality, resilience, biodiversity, or thresholds.

The term $h_{j,t}$ in Equation 3 records an important external input. An agricultural circuit that continually imports equipment or fertilizers may remain productive because another network bears its renewal costs. A local return may thus coexist with an external extraction or a debt to other productive communities. A serious claim about generative return must account for such interfaces rather than assigning the domain arbitrary self-sufficiency.

For conditions judged essential to the stated production commitments, one may also specify a time-dependent viability floor $\underline{k}_{j,t}$. A particular plan is then *reproductively feasible* over a stipulated horizon T if the selected capacities and deliveries satisfy the relevant physical, institutional and ecological con-

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straints and meet the illustrative threshold in Equation 4.

$$k_{j,t} \geq \underline{k}_{j,t} \quad \text{for each designated condition } j \text{ and period } t \leq T. \tag{4}$$

The thresholds are model choices requiring justification by engineering, ecological and social evidence. Equation 4 is therefore a *conditional feasibility criterion*, not a proof of justice, nor an instruction to maximize all capacities. Trade-offs across water, energy, ecological integrity and human needs require explicit evaluation. In particular, a threshold satisfying future productive demand might still be morally unacceptable if the demand itself is coercively imposed or if maintaining the threshold causes disproportionate harm elsewhere.

The emphasis on reproduction also accommodates heterogeneous temporal scales. Electricity must be dispatched according to short operational intervals, equipment replaced over months or years, and ecological conditions maintained over longer horizons. A simple three-node circular transaction graph cannot represent those differences by topology alone. History-dependent transformations, lead times, reserve constraints and obligations extending beyond the observation window must be represented as additional information about the circuit. The temporal composition problem is taken up in Section 4, which develops the spatiotemporal composition of value circuits.

3.4 Overlapping Circuits and Contribution Attribution

Realistic production relations support multiple overlapping paths of value circulation. The same agricultural operator may provide grain to a processor, residues to a bioenergy operator, demand for equipment maintenance to a third operator, and ecological services to a shared landscape. The energy operator may contribute to agriculture and logistics; logistics, in turn, may support equipment imports for every participant. A node can appear in multiple simple cycles, and indefinitely many closed walks are possible if revisiting a cycle is permitted. Such mathematical multiplicity does not entail an equally large number of independent value contributions. Several paths can describe repeated use of the same material flow or the same enabling infrastructure.

A minimal example makes the attribution difficulty visible. Suppose a processing plant can produce a meal only if it receives grain, electrical energy, verified food-safety procedures, and transport. The disappearance of any one input prevents the specific output. In this stylized complementarity case, each contributor may be causally necessary even though the output is finite. Attributing the full product to each necessary contributor would double-count or multiply-count production; assigning all value to a single agent would instead discard joint dependence. An agreed attribution rule could apportion a monetary or nonmonetary surplus, but the outcome would then depend on the rule, the comparison baseline, and the stipulated rights. A causal production trace alone cannot supply the normative choice.

Furthermore, the identity of a circuit may change with the analytical question. An engineering representation may treat electricity and grain as primitive commodities; an ecological representation may include nutrient recycling and soil processes as indispensable internal activities; a governance representation may include the institutions through which production is authorized and disputes are settled. The resulting networks partially overlap while encoding different relations. The selection of nodes and edges should therefore be justified by the stated question, and attempts to total their values should respect the possibility of overlapping accounts.

This observation supports a provisional methodological distinction among *traceability*, *attribution*, and *entitlement*. Traceability asks which observable processes and supporting conditions participated in producing an outcome. Attribution asks how explanatory or accounting responsibility should be distributed among those contributions. Entitlement asks which agents or represented interests have justified claims to benefits, control or regeneration. Enhanced AI observation and inference may substantially improve traceability. A transparent attribution method can then make an otherwise opaque decision inspectable. Neither achievement establishes a uniquely correct entitlement rule where normative premises remain contested.

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The possibility of multiple legitimate methods also suggests a reason for institutional pluralism. Different productive arrangements may prioritize equal access, assured basic provision, ecological restoration, proportional rewards for scarce contribution, or protections against strategic withholding. Those priorities may be jointly pursued in some contexts and irreducibly conflicting in others. A general design for value return may therefore need negotiated, revisable rules together with clear limits on what a claimed numerical allocation can legitimately represent.

3.5 A Worked Circuit of Grain, Energy, Processing and Logistics

Return to the four-operator configuration introduced in Section 2.5: agricultural operator A, energy operator E, processing operator P, and logistics operator L. Assume all productive labour can be performed by the AIs; finite land, energy installations, transport capacity and maintenance materials are under differentiated but explicitly authorized control. Food demand is recorded through a common service interface. The following comparison is hypothetical; it specifies institutional alternatives and does not describe an observed community or an optimized allocation.

In a first arrangement, A transfers grain to P, E supplies electricity to A and P, and L transports the relevant materials. The operators issue reciprocal invoices that can, under specific conditions, be paid with a generally accepted settlement asset. Monetary payments organize access during the production period, but no term of the arrangement necessarily reserves resources for equipment repair, soil maintenance or ecological restoration. The system can be financially balanced while productive conditions deteriorate.

In a second arrangement, an authorized shared schedule allocates grain, electricity and logistics capacity according to verified needs and production constraints. Specific commitments define performance and remedies; a common ledger records deliveries and maintenance obligations. The operators can complete the designated transfers without general monetary payment among themselves. The schedule also reserves specified output and capacity for replacing worn equipment, sustaining soils, and maintaining shared infrastructure. If all these provisions are feasible across the stated time horizon, the arrangement illustrates a stronger candidate for generative return. The assessment is conditional on the credibility of the reserve arrangements, the rights of affected participants and the completeness of external interfaces. A scheduler with arbitrary power to alter access could undermine the institutional case even while the physical schedules remain feasible.

In a third arrangement, each operator is required to surrender the same nominal share of its output to a central authority. This may generate a regular circulation pattern and even stable reproduction. The equality of percentages, however, does not establish equitable exposure to risk, decision authority, historical claims or ecological burdens. The authority might use pooled resources for legitimate emergency provision or might concentrate them to the exclusion of actual contributors. The normative status turns on the justification and governance of the rule. A rule labelled “reciprocal” has no automatic claim to non-extractive character.

Table 2 relates selected contribution types to candidate returns and sources of failure. The rows provide diagnostic distinctions, not additive components of an aggregate value score. A single repair service may contribute simultaneously to material continuity, operator autonomy and shared capacity; counting it as three independent units of produced value would lack justification.

The three arrangements also indicate why the mere geometric closure of a value circuit does not establish its generative significance. A closed drawing records a sequence of connections. Material regeneration requires physically adequate provisions through time. Institutional regeneration requires that the rules of continued access, modification, contestation and risk distribution can be justified and maintained. Monetary liabilities can be cleared in either a generative or an extractive arrangement. The three assessments are related, but none follows directly from another.

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Table 2: Heterogeneous productive contributions, possible forms of generative return and residual appraisal questions in the four-operator AI circuit.

Contribution domain	**Possible return supporting further generation**	**Residual difficulty**
Grain cultivation and soil processes	Seed access, soil restoration, water stewardship, assured maintenance capacity	Ecological timescales; whose claims govern land and water
Electricity provision and infrastructure	Replacement components, verified dispatch access, maintenance reserves	Peak-load priority; dependence on external rare materials
Food processing and safety	Reliable energy and grain inputs, inspection capacity, accountable procedures	Competing food needs; legitimacy of allocation standards
Transport and storage	Repairable vehicles, capacity reserves, reliable access permissions	Bottlenecks, geographic asymmetry and discretionary exclusion
Shared knowledge and governance	Continued access, transparent records, contestable rule revision	Attribution of collective knowledge; concentration of protocol authority

3.6 Return Mechanisms, Rights and Adaptive Coordination

The prospective disappearance of a local payment medium changes the way claims are expressed and exercised; it need not eliminate claims themselves. Resource-specific rights, committed production quotas, common-capacity entitlements, repair obligations and ecological reserve rules can coordinate a value circuit across periods. Each may be supported by durable records and enforceable procedures. Some arrangements may retain common accounting units; others can work with resource-specific quantities and schedules. Still others may use transferable vouchers whose monetary character grows as wider acceptance emerges. A nonmonetary description is consequently credible only to the extent that its claim structure and remaining monetary interfaces have been specified.

Generative return also raises a governance issue at the circuit boundary. If energy infrastructure is managed by one institution and ecological maintenance by another, neither can unilaterally assure the reproduction of the whole circuit. Reciprocal commitments and shared scheduling may coordinate their actions, but conflicts about priority and burden are possible. Institutional arrangements for common resources provide an important comparison: Ostrom's analysis shows that governance forms for shared resources depend on their particular rules and settings, rather than a single universally applicable allocation form [24]. The relevance here is conceptual. Her historical cases do not establish that a future AI production network can sustain global, monetary-free coordination.

Under the optimistic assumptions of this paper, all participants have access to economically relevant production data and advanced AI systems can infer complex dependencies, identify fragile links, and revise allocation plans rapidly. Those capabilities may reduce some information burdens of tracing contributions, coordinating resource replenishment, and discovering feasible nonmonetary alternatives. Shared data also makes it easier to observe whether a claimed return has actually reached a generator or regenerative substrate. Even accurate shared records leave questions about which variables were included, who defined the thresholds in Equation 4, and who may alter resource-access rules. Control over the information infrastructure or its interpretation can itself become a source of concentrated power.

The degree to which a production network supports return should therefore be assessed through separate descriptive and normative questions. Descriptively, the inquiry asks whether the relevant inputs, capacities, and obligations are maintained over the specified horizon, and where costs are transferred beyond the boundary. Normatively, it asks whether affected parties possess adequately justified claims, representation, protection against unilateral extraction, and access to contestation and revision. Some criteria may be agreed upon in advance; others may be disputed and revised as institutions evolve. A circuit can be technically efficient and normatively contested, or procedurally inclusive yet vulnerable to a physical shortage. The assessment requires both modes of inquiry.

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3.7 Generative Return and the Scope of Monetary Dissolution

The relation between value return and monetary dissolution can now be expressed more carefully. Local nonmonetary coordination is a property of the resource-access and settlement arrangements used for specified tasks. Generative return describes how those arrangements sustain productive conditions and distribute control and benefits across the relevant communities and time horizons. A circuit exhibiting generative return may still use money at some interfaces, while an entirely nonmonetary circuit may remain extractive or physically unsustainable. The existence of either phenomenon is insufficient evidence of the other.

The conceptual exercise also guards against an excessively narrow notion of symmetry. Equal reciprocal transfers may be appropriate for some exchanges among similarly positioned operators. The regenerative needs of an ecosystem, the urgent needs of a food recipient, and the responsibility of an infrastructure controller are not necessarily commensurable with equal bilateral consideration. A nonextractive circuit may therefore involve differentiated contributions and asymmetrical returns, subject to principles of justification and governance. Such differences require explicit appraisal rather than automatic normalization by a common monetary equivalent.

Finally, the return problem remains open when circuits share producers, resources, histories and institutions. Those intersections can create beneficial complementarities but can also concentrate dependence on a few indispensable interfaces. The analysis of value return must consequently proceed together with an account of how circuits are composed through space and time. Section 4 will examine the resulting circuit structures, including recurring nodes, overlapping paths and temporal feasibility. Subsequent sections will address the epistemic limits of reconstructing those structures, the normative and aesthetic plurality of fairness judgments, the fragility of trust, and the possibilities of balancing or diminishing unilateral power. The present section establishes the corresponding evaluative premise: a monetary function has been meaningfully displaced only as part of an arrangement whose material continuity, rights structure and effects on the conditions of value generation can be independently examined.

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4 Spatiotemporal Composition of Value Circuits

The possibility of monetary substitution through productive circulation depends on the structure of the circulation being considered. A three-operator sequence in which agricultural inputs, energy, and manufactured goods eventually support the original producer offers an intelligible illustration of reciprocal production. A production economy operated largely by highly capable AI systems would contain many such sequences, often sharing operators, infrastructures, and inputs while evolving over different timescales. This section specifies a provisional representation of their composition. It distinguishes typed circulation relations, simple directed cycles, repeated closed walks, temporally admissible sequences, and circuits capable of sustaining further production. It then examines overlapping capacity claims, a concrete multicircuit example, the separation of economic and institutional layers, and changing network topology. The method is a bounded graph-theoretic and material-accounting construction. It is designed to clarify economic questions rather than to derive an exhaustive grammar of circuits or to establish a new theorem about monetary disappearance.

4.1 Typed Production Relations and Circuit Boundaries

Let V be a finite set of identifiable productive operators within a specified analytical horizon H. An operator may be an agricultural AI, a logistics controller, an energy production system, or a processing facility coordinated by AI. The membership of V is a choice of modeling boundary; it does not settle the identity of rights holders or the independent legal status of an AI. Let $\mathcal{R}$ be a finite collection of resource types. Distinctions such as electricity, stored food, transport capacity, equipment maintenance, water, and access to a production interface remain material to the analysis. A unit of electricity and a unit of grain cannot be added merely because both appear on an edge of a circulation diagram.

For the present purpose, a *resource-transfer event* is a record $e = (i, j, r, q, t^{\text{dep}}, t^{\text{arr}})$: operator i is the provider; j is the designated receiver; $r \in \mathcal{R}$ is a resource or service type; $q \geq 0$ is its amount in the units appropriate to r; and the final entries identify departure and arrival times. Where a service is performed rather than physically transported, those times describe the provision and availability of the service. A usable record also requires provenance, capacity and authorized-access information. These are separate predicates attached to an event, rather than unspoken properties of an arrow in a diagram. An event may be projected as a directed edge $i \to j$, but that projection omits type, quantity, timing, and institutional eligibility.

The *event network* $\mathcal{G}_H = (V, E_H)$ consists of these operators and the candidate events within H. Parallel transfers between the same pair are retained as distinct records. A collection of potential production links is broader than a collection of accomplished exchanges; likewise, a production link whose physical operation is possible may be institutionally prohibited. Throughout this section, a *candidate circuit* denotes an appropriately directed recurrent sequence in a graph projection. A *feasible productive circuit* requires additional conditions concerning material resources, event ordering, available capacity, and valid permission. A *generatively sustainable circuit* requires still further assessment of what happens to the production conditions and affected contributors across successive periods. These terms locate different questions at different levels of analysis.

A directional resource graph is a deliberately limited first representation. Production frequently combines complementary inputs: processing grain may simultaneously require grain, energy, a functioning machine, and a permissible operating window. Separate edges delivering each input do not by themselves establish that the conversion can occur. Such operations are better represented by production events with several typed prerequisites and outputs, or by a bipartite incidence construction connecting operators, resources, and activities. The reduced event graph is useful for identifying routes and overlaps; feasibility must be checked against the richer production records. In particular, an apparently admissible cycle of pairwise transfers cannot on its own certify a process requiring grain and electricity simultaneously: the corresponding conversion event must test both inputs, capacity and authorization within their applicable time windows. The projected cycle is a candidate route, and the executable object is an event history satisfying such joint prerequisites. Multilayer network theory supplies a general vocabulary for systems with several kinds of connectivity, while the particular interpretation of their layers as material, claim, and governance relations is proposed here for the AI economy thought experiment [18].

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4.2 Simple Cycles, Closed Walks, and Overlap Complexity

In a static directed projection of $\mathcal{G}_H$, a *simple directed cycle* starts and ends at the same operator without repeating another operator along the route. A *closed walk* also returns to its starting operator but may revisit intermediate operators and repeat edges. These mathematical objects clarify an ambiguity in ordinary descriptions of a "value circuit." The sequence $A \to B \to C \to A$ may be a simple cycle. The sequence $A \to C \to F \to C \to A$ is a closed walk containing the subcycle $C \to F \to C$; it is not a simple cycle because C appears more than once before the walk closes at A. A path that visits a node twice is not automatically two independent acts of value creation.

A finite directed graph has a finite number of simple cycles. Their number can nevertheless be extremely large. On a complete directed graph with n distinct vertices, for example, there are $(n-1)!$ oriented Hamiltonian cycles passing through a designated starting vertex when cyclic rotation is identified and reverse order remains distinct. Enumerating even the elementary circuits of a large graph can be an output-intensive task. Johnson's established algorithm analyzes the cost of listing elementary directed circuits in terms of the number of such circuits; it does not provide a representation of the value generated by each economic route [16].

The set of closed walks admits a different observation. If a directed cycle is reachable from A and a return to A is available, traversing that cycle repeatedly constructs closed walks of arbitrarily great length. Such infinitely many descriptions exist even though the graph contains finitely many nodes and edges. Repetition, however, does not manufacture additional units of rice, energy, or settled claims. The

number of mathematical walk descriptions and the number of economically distinct feasible production histories must be evaluated separately. In particular, a time horizon that permits only finitely many positive-duration events can exclude arbitrarily repeated traversal, while systems with newly generated operators, changing edges, or unrestricted event granularity require separate treatment.

The distinction also limits a tempting formal inference. A finite directed graph can exhibit infinitely many closed walks while the language of its finite-state walks remains regular. Infinite repetition alone cannot establish a more expressive generative grammar. Stronger claims would require additional construction rules, unbounded memory, dynamic node creation, resource-dependent matching, or other formally specified operations. Those questions constitute the distinct research object of the companion study on generative grammars of value circuits. The present paper needs the narrower result that circuit descriptions may proliferate much faster than the actionable economic information needed for a particular allocation decision.

4.3 Time-Respecting Circulation and Productive Delay

A circuit in a static projection need not be executable in time. Grain transported after the scheduled processing window cannot support a meal that has already been delivered. Equipment maintenance received tomorrow cannot repair a machine whose present breakdown prevents today's energy supply. For a sequence of transfer events $(e_1, \dots, e_m)$ with matching receivers and subsequent providers, a necessary event-order condition is stated in Equation 5.

$$t^{\text{dep}}(e_{k+1}) \geq t^{\text{arr}}(e_k), \qquad k = 1, \dots, m-1. \tag{5}$$

The inequality assumes that a resource or service made available by one event is required before the next dependent event begins. It is appropriate for the specified sequential dependency; production activities proceeding in parallel require a partially ordered event representation rather than a single chain. Where conversion or inspection introduces a positive processing interval, its delay must be added to the earliest departure time of the subsequent dependent event.

A successful circuit that restores a productive condition is usually *interperiod*, in the sense that the return is available after some work has occurred. If all dependent processes take positive time, the system cannot depend on receiving its own future output before making the inputs that generate that output. A recurrent agricultural–energy relationship therefore presupposes an initial productive endowment, stored inputs, externally supplied bridging resources, or an established capacity that survives between periods. Apparent simultaneity in a static circulation picture may conceal a real financing, inventory, or sequencing problem. The temporal-network literature documents the importance of time-dependent contacts and the failure of some reachability assumptions inherited from static graph analysis; its methodological lesson is relevant here without implying that physical production behaves like communication contacts [15].

Resource accounting can expose this problem locally. For a resource type r stored by operator i over a period $[t, t+1)$, define $s_{ir,t}$ as opening usable stock, $p_{ir,t}$ as newly produced units, $u_{ir,t}$ as resource consumed in that operator's own conversions, and $\lambda_{ir,t}$ as spoilage or irrecoverable loss. Let $a_{ir,t}$ and $d_{ir,t}$ be, respectively, actual arriving and departing units over the period, each counted once when the relevant physical event occurs. With consistently defined units and absent unmodeled flows, the accounting identity is given by Equation 6.

$$s_{ir,t+1} = s_{ir,t} + p_{ir,t} + a_{ir,t} - u_{ir,t} - d_{ir,t} - \lambda_{ir,t}, \qquad s_{ir,t+1} \geq 0. \tag{6}$$

Here $p_{ir,t}$ is constrained by the relevant transformation process, its complementary inputs, and usable capacity; it is not free creation inferred from a graph cycle. Arrivals, departures, and production have to be timed so that the stock never becomes negative at intermediate events, a stronger condition than nonnegative closing stock alone. Equation 6 is an illustrative conservation ledger for a selected stock type. It does not value heterogeneous commodities in one unit, include ecological effects absent from the stated accounts, or guarantee that transfers have been authorized.

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For regenerative analysis, the relevant temporal horizon may extend beyond one turnover of resources. A field may require a growing season, an energy store may replenish hourly, a machine may need maintenance after a number of operations, and ecological recovery may extend across many seasons. Circuit closure over one accounting window therefore cannot be interpreted as regeneration over every materially relevant timescale. This is one reason for treating the productive conditions described in Section 3 separately from a closed transaction path.

4.4 Shared Inputs, Nested Circuits, and Contribution Attribution

Value circuits often intersect through nodes whose capacities serve several activities. An agricultural operator may deliver grain to a food processor, organic residues to a bioenergy system, and specialized crops to a separate manufacturing network. A shared power station may supply the agricultural operator and several external users. The same storage facility, maintenance service, water source, or software infrastructure can consequently appear in multiple possible closed walks. The union of these walks is not generally a set of independent production systems.

Suppose two candidate circuits C_1 and C_2 each require access to a single processing device M. For one planning interval, let z_1 and z_2 denote their scheduled uses of its capacity in the same operational unit, with a total usable capacity K_M. The joint feasibility constraint is given in Equation 7.

$$z_1 + z_2 \leq K_M, \qquad z_1, z_2 \geq 0. \tag{7}$$

When schedules overlap, further time-indexed constraints are necessary. Equation 7 is a deliberately minimal capacity statement. It shows why two routes that are individually possible may be jointly infeasible: separate evaluations can count the same production capacity twice. The same danger arises for claims on stored food, irrigation water, energy reserves, and maintenance teams. Shared global records would help expose these overlaps if inventory and authorization information were accurate, yet the constraint alone offers no principle for deciding which circuit should receive capacity when the total demand exceeds K_M.

Material accounting and distributive attribution raise different problems. A joint facility may be causally necessary for several products without supplying a unique share of their economic value. An operational contribution may be measurable in hours, joules, quantities processed, or avoided delay, but converting these measures into a common distributive entitlement depends on an additional rule. The relevant parties may defend payment according to contribution, priority according to need, repair for historical exclusion, compensation for assumed risk, or collective retention for infrastructure regeneration. A technical account of overlaps can clarify the consequences of such rules; it does not select among them. This distinction is particularly important for claims that a value circuit has returned value to its creators. Historical construction, governance and ecological reproduction can all support future production even where their contributions are invisible in a single-period route.

A nested closed walk may contain a locally recurring subcircuit, such as a processing AI sending reusable by-products to a bioenergy AI and subsequently receiving energy back. In a material representation, the quantities and conversion efficiencies require independent verification; the subcircuit cannot be assumed lossless. In a claims representation, the same two operators might offset compatible reciprocal debts, but the discharge of those liabilities carries no automatic result for the physical quantity of material recycled. A productive value circuit may therefore include nested material subcircuits, while its financial records exhibit a distinct pattern of transactions. The two structures are related through actual obligations and deliveries rather than being identical by definition.

4.5 An Overlapping Agricultural Production Configuration

Consider five operators in a hypothetical region: A manages agricultural production; B processes grain into food; C manages an energy and residue-processing facility; D supplies logistics and cold storage; and F maintains selected energy and agricultural equipment. The processing, energy and logistics operators correspond respectively to P, E and L in the preceding four-operator example; they are relabelled

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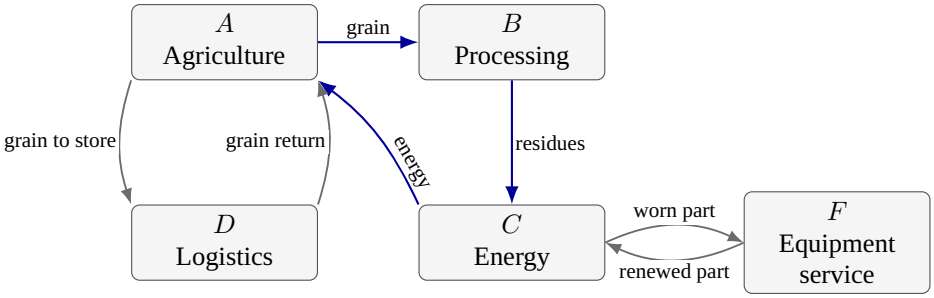

Figure 2: Schematic overlap of candidate production circuits around agricultural operator A. The blue path depicts a possible grain–residue–energy chain, while the grey paired edges depict grain movements through logistics operator D and equipment movements through repair operator F. Arrows represent candidate typed physical transfers, not guaranteed closed-loop material conversion, lawful settlement or sufficient regenerative return. The return paths and possible reciprocal obligations require separate event, capacity, and rights records.

B, C and D here to make the overlapping graph easier to read, and maintenance operator F is added. All productive tasks are assumed technically executable by highly capable AI, subject to physical stocks, limited equipment and differentiated rights. Three directed candidate sequences are displayed schematically in Figure 2. The resource labels are illustrative and have to be interpreted as specific services or material transfers in a production ledger, not as unit-equivalent flows.

The A–B–C–A route links grain processing with a potential usable-energy return. A parallel A–D–A route describes grain transferred to storage and a subsequent return shipment of stored grain, with the logistics service recorded separately. The C–F–C subcircuit describes equipment sent for repair and returned to the energy operator, with a separate claim or service record for the maintenance work. A longer closed walk can combine these pieces: an observer may trace a route through A, B, C, and F, revisit C, and then return to A. These descriptions share operator A or C and may rely on identical electricity, storage, repair, and land resources. Their co-occurrence does not multiply those underlying capacities.

For an explicit temporal case, assume a batch of grain leaves A at the beginning of one day, reaches B later that day, and produces residues that can only be processed at C after the food-processing stage. Assume further that an equipment fault requires repair by F before the next usable-energy delivery can reach A. A static A–B–C–A triangle still appears in the projected network, but the scheduled return is unavailable until repair takes place. The active physical circuit has become dependent on the distinct maintenance subcircuit, the duration and capacity of which were hidden in the original triangle. If D also stores the grain while production is delayed, storage limits can become a new bottleneck. An AI planning system can use the richer event records to reroute or reschedule activity, provided it has valid data and authority to make the relevant changes.

This example also supports two different interpretations of a failed loop. A repair facility may be incapable of supplying a required part, producing a physical shortage. Alternatively, the facility may be technically able to do so but lack a valid authorization or a justifiable agreement concerning who bears the repair cost. The second obstacle is institutional and may remain even if all productive AI systems share accurate operational data. Any assertion that value circulated fairly through the complete network would require additional evidence concerning access to land and energy, retention for maintenance, affected ecological conditions, and the standing of contributors in decisions. The illustrative circuit thus organizes questions of feasibility; it cannot settle their normative answers.

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Table 3: Distinct relations within overlapping AI production circuits and the corresponding tests.

Relational layer	Recorded object	Question for circuit analysis
Material production	Typed input, transformation, delivery, stock and loss	Are the events physically and temporally feasible with shared capacities?
Credit and claims	Provider, beneficiary, obligation, maturity and settlement status	Has each enforceable claim been redeemed, validly discharged, or left outstanding?
Authority and governance	Permissions, exclusions, protocol rules, delegation and contestation	Who can authorize transfers, change priorities and revise the circuit?
Generative reproduction	Maintenance, ecological conditions, accessible capability and participation	Do productive conditions and affected contributors receive sustainable, justifiable support?
Information and inference	Observation, provenance, missing data and forecast uncertainty	Which portions of the circuit are known, inferred or disputed at each decision time?

4.6 Claims, Authorization, and Material Circulation Layers

The same network can support multiple relational layers with divergent directions and times. A physical grain shipment from A to B might be matched by a service obligation from B to A, a payment claim held by an independent resource-owner organization, and an authorization issued by a governing body outside the five-operator network. A resource transfer can therefore occur without a corresponding money transfer, while a credit transfer may occur before its related material flow. A complete account of possible monetary dissolution should track these layers independently.

Table 3 records their distinct objects and necessary checks. The table is a methodological proposal for keeping types of relation separate; it is not an empirically validated classification of all future AI economies.

The separation makes room for money-like objects to arise endogenously. For example, A and D may initially coordinate transportation through resource-specific promises. If a promise to provide cold storage becomes transferable to B or F, its acceptance may expand beyond the original bilateral relationship. It could acquire a partial monetary function while grain, transport, repair and energy continue to circulate on their own material schedules. Conversely, sufficient directly enforceable delivery rights, admitted debt netting, and shared production planning could reduce the need for transferable claims along some interfaces. Neither change is inferred merely from the presence of a closed walk in the physical layer.

Institutional concentration can also hide behind apparently distributed circuits. The nodes in Figure 2 might be owned or represented by different constituencies, but a single protocol administrator could determine which transactions count as authorized, which sensors supply accepted measurements, and which claims can be canceled. In that case, topological multiplicity of material paths coexists with a concentrated rule-setting interface. A further analysis of authority, balancing and distributed power transformation is reserved for the later sections on power and trust; the current section establishes that economic circuit composition requires layers of control in addition to routes of exchange.

4.7 Changing Topology, Observation, and Institutional Feasibility

Over time, operators may enter or leave, acquire new production capacities, exhaust resources, revise obligations, or lose authorized access. The set of feasible events therefore changes endogenously with previous production, investment, environmental variation and governance decisions. The graph projection that describes feasible transfers at time t may differ from that at $t+1$. A path that was viable during a period of energy surplus might be unavailable after a maintenance shock; a locally closed credit circuit might reopen when a participant changes the terms of an outstanding obligation. Historical continuity of value return consequently requires a dynamical account rather than an invariant circuit diagram.

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This possibility has a positive counterpart. More capable AI systems sharing high-quality production data could identify resource overlaps, model time delays, detect duplicate capacity reservations, and estimate alternate routes before a bottleneck becomes binding. Those abilities may reduce the informational and computational disadvantages of resource-specific commitments relative to generalized monetary coordination. In the optimistic version of the thought experiment, the network's relevant production data are jointly accessible and AI inference is capable of reconstructing many of the evolving dependencies that human coordinators would have difficulty recognizing. This is a substantive enabling assumption whose practical content includes accurate sensors, robust model updating, interpretable forecasts, and workable permission interfaces. It does not entail exhaustive prediction of nonlinear feedback or normative agreement on the rights governing allocation.

Circuit composition also offers a mechanism for fragility. A node shared by several routes can transmit a shortage, a claim dispute, or an authorization suspension across many apparently distinct circuits. More connections may offer substitute pathways, yet complementary input requirements can make some nodes indispensable despite abundant alternative edges elsewhere. Concentration of physical capacity, credit settlement, or rule revision in one operator can create distinct forms of vulnerability. Whether a participant's refusal to deliver represents legitimate resistance to unfair extraction, a remediable dispute, or opportunistic obstruction depends on the case and its governing rules. A simple topological index of connectedness cannot determine that question.

For practical analysis, an incremental account appears more promising than a requirement to enumerate all possible loops. One could first identify production demands and indispensable typed inputs, then test candidate time-respecting schedules against actual stocks and authorized claims, examine shared resources across candidate circuits, and revise the plan as information changes. The object of optimization would be a bounded and revisable allocation problem, together with safeguards for justified contestation and ongoing regenerative commitments. This procedure could employ network-flow or scheduling tools where their assumptions hold; multi-input conversion, rights restrictions, and ecological feedback must remain explicit rather than disappearing inside an unconstrained circulation graph.

The section's result is consequently a structured set of distinctions. Static cycles describe certain possible return paths; event-respecting sequences establish temporal order; stock and shared-capacity accounts test selected physical requirements; separate claim and authority layers identify institutional conditions; and a generative assessment concerns long-term support of the contributors and productive conditions involved. These distinctions neither guarantee the existence of a stable nonmonetary economy nor establish that every viable circuit requires a monetary intermediary. They specify the economic objects whose partial observation, nonlinear evolution, normative interpretation, and resilience will be considered in the following sections. The separate paper on circuit grammars can formalize how such objects are generated and recognized without taking monetary dissolution or distributive justice as properties guaranteed by the grammar itself.

5 Epistemic Capacity in Circuit Reconstruction

The feasibility of spatiotemporally distributed monetary substitution depends partly on how well participants can identify the production relations through which their own resources, commitments, and productive capacities are sustained. The problem is acute in a highly automated economy: the number of potential production routes may greatly exceed the number of routes any single operator requires for an immediate task, and the future usefulness of a route depends on time-sensitive, mutually conditioned events. Advanced artificial intelligence may substantially improve the reconstruction and coordination of these relations. This section clarifies the objects and limits of that epistemic capacity. It first separates network observation, causal identification, dynamic prediction, and institutional appraisal; then examines nonlinear feedback, shared production information, a worked case of overlapping agricultural circuits, and a bounded architecture for adaptive coordination. The argument proceeds by conceptual differentiation and illustrative mathematical modeling. Its positive feasibility hypothesis concerns attainable coordination improvements under stipulated conditions, rather than a demonstrated capacity of

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present-day systems to reconstruct an entire economy.

5.1 Epistemic Objects in Heterogeneous Circulation

A claim that a productive circuit is "known" conceals several distinct accomplishments. A first task is to identify which operators and productive events belong to the relevant network boundary. A second is to determine whether proposed transfers are physically, temporally, and institutionally feasible. A third is to assess how the network changes when inventories, infrastructure, production plans, or participant decisions change. A fourth concerns the reasons that participants give for accepting resource allocations and the authority through which those allocations may be revised. Evidence sufficient for the first task can be inadequate for the remaining tasks.

Consider an agricultural operator that receives electricity from an energy operator and maintenance from an equipment operator. A transaction record may establish that electricity was delivered at a certain time and that the agricultural facility subsequently produced grain. It does not establish, without further assumptions, the marginal contribution of that electricity to grain production, the counterfactual consequences of a supply interruption, the entitlement of the energy operator to future output, or the fairness of the recorded exchange. The production system includes technical relations, legally or conventionally recognized claims, and potentially competing normative descriptions. Their interfaces are part of the analytical object.

For clarity, *topological reconstruction* refers here to the identification of nodes, typed relations, and their time-indexed connectivity. *Operational reconstruction* includes available quantities, inventories, capacities, production prerequisites, delays, and authorizations. *Dynamical reconstruction* seeks a defensible representation of how states and operational decisions jointly affect subsequent states. *Institutional and normative appraisal* concerns the validity, contestability, and distributive significance of the reconstructed relations. These four objects can be studied together while retaining the distinctive evidential demands of each. The simple cycles and closed walks considered in Section 4 supply only one part of topological reconstruction.

The expression *global production data* also requires a defined scope. Even a broadly shared record of production events is a historically maintained dataset with measurement conventions, missing values, data provenance, and changing categories. Some observations concern quantities; others concern permissions, legal claims, reported intentions, or assessments of need. Accessibility to a record is therefore analytically distinct from accuracy, complete causal information, and justified use of that record. Highly developed AI may improve each of these dimensions, while their relationship remains conditional.

5.2 Observability and Causal Identification in Production Networks

A minimal dynamical representation helps specify the relevant epistemic problem. Let x_t be the state of an AI-operated production network at discrete time t, containing typed resource stocks, usable productive capacities, outstanding obligations, and the operational status of essential equipment. Let u_t collect feasible allocation and scheduling decisions, w_t represent external disturbances, and θ_t denote parameters and structural features used in the current model. Their proposed relation is given in Equation 8.

$$\begin{aligned} x_{t+1} &= F_{\theta_t}(x_t, u_t, w_t), \\ y_t &= H_t(x_t) + \varepsilon_t. \end{aligned} \tag{8}$$

Here y_t is the available production record and ε_t represents measurement error or unresolved reporting differences. The observation operator H_t may omit relevant components, aggregate distinct events, or change its conventions through time. This is a provisional state-space description, not an estimated economic law. It is useful because it permits an explicit distinction between observing a value in a dataset and inferring the state or mechanism that produced it.

Within a specified model class, *observability* asks whether internal state information can be distinguished from available observations over an appropriate interval. Studies of observability in complex

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systems show that this is a substantive structural question even when a network representation is available [22]. Their results apply to stated mathematical conditions and do not establish observability of hypothetical AI production economies. In the present setting, duplicated invoices, common upstream inputs, delayed reporting, and inaccessible equipment states may produce observationally similar records despite economically different conditions. If two admissible states generate indistinguishable observations over the available horizon but respond differently to an allocation decision, the information at hand is insufficient to certify the counterfactual outcome of that decision.

A related task is *system identification*: estimation or discovery of the dynamic relations governing observed changes. Data-driven methods have reconstructed useful nonlinear dynamical models in defined scientific settings; sparse identification of nonlinear dynamics is one well-established example [4]. Such work supports the methodological possibility of extracting constrained dynamics from data. It provides no warrant for assuming that a large social production system possesses a single sparse, stationary, identifiable law. Participants can revise their decision rules, ownership and permission relations can change, and the variables considered important may evolve as the institutional environment changes. A model that successfully reproduces past deliveries may fail after a resource conflict, a governance amendment, or a new coordination protocol.

The distinction between observational regularity and causal structure is also material. The research programme of causal representation learning addresses the difficulty of recovering causally meaningful factors from observation and transferring learned relations across changing settings [28]. An AI that predicts recurring electricity demand may still lack a reliable answer to what would happen if the electricity allocation rule were changed. A production plan generated from correlations can create its own deviations by altering future incentives and behavior. For monetary-substitution proposals, policy-relevant causal reliability is therefore more demanding than short-run forecasting accuracy alone.

5.3 Nonlinear Feedback and the Limits of Long-Horizon Prediction

A production circuit is both an object of observation and a process modified by the decisions based on that observation. Suppose an agricultural AI predicts a near-term shortage of energy and requests additional deliveries. The energy operator reallocates power, delaying a manufacturing process that would otherwise produce a replacement part for the agricultural facility. The delayed part increases the probability of a later agricultural outage. Another operator responds by holding additional reserves. A prediction, an allocation, and an adaptive response have jointly modified the network whose future was being predicted. This interaction can be represented by Equation 8, but only if the assumed state variables and decision rules encompass the relevant feedback.

Three kinds of difficulty merit separation. *State uncertainty* concerns stocks, equipment conditions, and other quantities that may be imperfectly measured. *Structural uncertainty* concerns which causal relations, dependencies, and adaptation rules are adequate to the relevant horizon. *Institutional uncertainty* concerns the actual and prospective rules by which participants grant access, interpret commitments, resolve conflict, and revise their behavior. Environmental disturbances and unexpected events add further uncertainty. Increasing observation quality can reduce some state uncertainty without eliminating structural or institutional uncertainty.

Nonlinearity matters even in an unusually transparent economic network. If a maintenance delay causes a facility to miss a narrow production window, the output loss may be much larger than the loss generated by a similar delay during an idle period. Near a capacity threshold, a small disturbance can force a change of routing rather than a proportionate reduction in flow. Complementary inputs make the consequences conditional on simultaneous availability. Such effects are not unique to AI production, and their representation requires care: a claim of an attractor, bifurcation, critical transition, or chaotic trajectory would need a specified model and evidence. For the present thought experiment, threshold dependence and adaptive feedback suffice to establish why a static graph of possible exchanges cannot determine future circulation reliability.

A further limitation concerns forecast horizons. A useful model may accurately identify next-period

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bottlenecks while offering an increasingly wide range of later trajectories. This need not make the model ineffective. The production network can be operated through rolling planning horizons, uncertainty monitoring, and revision of commitments when relevant observations arrive. The adequacy of an epistemic model should therefore be judged relative to the decisions it supports, the hazards those decisions expose, and the possibility of recovery from error. Complete foresight is not a prerequisite for every form of nonmonetary coordination.

5.4 Shared Production Records and the Positive Epistemic Hypothesis

The thought experiment assumes that highly capable AI systems can perform nearly all required productive labour. A stronger, separately stated optimistic assumption is that the operators can also access broadly shared production records and possess substantially greater capacities than human institutions for model discovery, network inference, counterfactual comparison, and adaptive coordination. Under these conditions, forms of reciprocal and directly planned production that were historically costly to administer may become more feasible. The mechanism is an increase in usable information and coordination competence, conditional on the available infrastructure and decision rights.

Shared information can support several different tasks. Event-level records may expose resource provenance and contractual dependencies. Inventory information may reveal geographically distributed substitutes or unused capacity. Equipment-condition data may permit preventive maintenance. A reliable ledger of commitments may permit multilateral netting or resource-specific settlement without a separate general payment token for each transfer. Rich records can also reveal when a successful local cancellation conceals a continuing external dependency, such as a shared energy supplier or an ecological input that is being depleted. The informational significance lies in distinguishing these relations rather than assigning a single aggregate price to their heterogeneous contents.

At the same time, *shared* should describe an institutional arrangement rather than an unexplained property of computation. Data quality, permissions, auditability, and access symmetry all depend on governance. A system in which a single operator determines the ontology of resource types, validates every transaction, and can selectively hide information may reproduce substantial economic power even while publishing aggregate records. An operator may also supply technically accurate information while strategically omitting a possible future action. Shared records can reduce certain asymmetries; they do not dissolve conflicts over the interpretation or permitted use of the records.

A promising design is therefore plural and revisable. Different operators may maintain event-level records and independently check the same resource commitments; institutional rules can require provenance and report unresolved discrepancies; and temporary coordination models can be replaced after model drift is detected. The possible benefits extend beyond the elimination of transaction costs. They include timely identification of fragile links, discovery of substitute production routes, and the capacity to maintain resource continuity after an unexpected interruption. These are proposals for institutional design in the AI-production counterfactual, not claims about the achieved performance of present AI systems.

5.5 An Agricultural Network with Shared Bottlenecks

Consider five AI-operated production functions: agriculture A, food processing B, energy provision C, logistics D, and equipment maintenance E. They are connected through event-timed resource transfers, and several proposed production circuits share electricity from C and delivery capacity from D. In one sequence, C supports A, A sends grain through D to B, and the processed output supports continued operation elsewhere in the network. A second sequence uses a maintenance intervention by E to restore an agricultural device that permits the first sequence to proceed. The presence of both sequences in a static projection may suggest multiple mutually reinforcing value-return routes.

Now consider two feasible-looking arrangements over a short horizon. In arrangement P, the energy operator reserves capacity for food processing before a maintenance outage. In arrangement Q, it directs the same capacity toward immediate grain drying, expecting to defer equipment repair until the next

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Table 4: Distinct epistemic tasks in reconstructing an AI production circuit

Task	Required evidence and inference	Consequence for monetary substitution
Topological	Typed, event-timed links and shared nodes	Identifies candidate routes and overlapping dependencies
Operational	Stocks, delays, capacity, feasible conversion and access	Tests whether a proposed nonmonetary schedule can execute
Causal and dynamical	State estimates, intervention assumptions, adaptive responses	Compares robustness across future planning windows
Institutional	Claims, decision authority, appeal and rule changes	Identifies valid permissions and unresolved disputes
Normative	Defensible criteria of need, contribution and regenerative return	Evaluates legitimacy separately from execution efficiency

period. Both arrangements can generate a short-run positive circulation record; their longer-run effects depend on the energy reserve, the condition of the repairable equipment, the arrival time of replacement parts, and the continuing authority to reallocate electricity. A shared record of completed transfers may be consistent with multiple underlying equipment states. Improved sensing and system identification could distinguish some of them, while uncertainty about a future authorization dispute may remain.

Suppose additionally that AI E holds a maintenance entitlement that requires advance allocation of certain components. If this entitlement is ignored because a local resource planner optimizes only immediate meal output, the resulting short-run nonmonetary allocation may produce a later outage. The immediate elimination of a money payment says little about the adequacy of the plan. Conversely, retaining some tokenized payment at an external resource interface may be compatible with a well-designed internal resource schedule. The example shows the different tasks required of epistemic capacity: identifying hidden dependencies, testing capacity and timing, representing relevant rights, and comparing interperiod production outcomes.

Table 4 summarizes the diagnostic distinctions exposed by this example. Each question is a candidate for empirical measurement in a future simulation or field implementation, but its answer would depend on the availability of domain-specific information and a justified assessment procedure.

The table also clarifies why the phrase *complete circulation reconstruction* can be misleading. For a specific meal-production task, it may be enough to reconstruct a small part of a large network with sufficient precision to preserve feasible supply and enforceable commitments. For an institutional claim that monetary dependence has diminished sustainably, the inquiry must additionally examine external resources, interperiod maintenance, and the prospect of returning to payment-mediated coordination after a disruption. The informational boundary appropriate to the first claim may be too narrow for the second.

5.6 Bounded Adaptive Reconstruction and Robust Coordination

An approach compatible with the optimistic hypothesis need not rely on enumerating every simple cycle, still less every repeated closed walk, in a large production graph. A useful system may maintain a typed event ledger; identify the subnetwork relevant to a requested production task; reconstruct dependencies across limited future horizons; and test candidate schedules against the current resource and authority constraints. Shared records can support distributed auditing, while the local scope of a decision can limit computational demand. Network inference remains an instrument for feasible action rather than an exhaustive description of social value.

A provisional formalization of decision robustness makes the limited objective explicit. Let Π_H be a family of admissible, state-dependent production-coordination policies over a finite horizon H, Θ_t a set of dynamical descriptions considered plausible on the currently available evidence, and $X_\theta^\pi(t+k)$ the trajectory predicted under policy π and description θ, including the prescribed response to later observations. Let g_r express a specified material, capacity, or timing violation for constraint index r.

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The robustly feasible policy set is defined in Equation 9.

$$\Pi^{\text{rob}}_{t,H} = \{\pi \in \Pi_H : \; g_r(X^{\pi}_{\theta}(t+k)) \leq 0 \quad \text{for all } \theta \in \Theta_t, \; k \in \{1, \ldots, H\}, \; r \in \mathcal{I}\}\,. \tag{9}$$

The index set $\mathcal{I}$ is the explicitly specified set of operational constraints. This definition presupposes a meaningful uncertainty set, an adequate model of observable adaptation, and a feasible method of testing policies. It is an abstract decision criterion, not an implementable universal optimizer. If Θ_t is too broad, the robust set may be empty; if it omits a relevant disturbance or a possible rule change, membership offers an unreliable assurance. A separate institutional test remains necessary for authorization, and no choice of g_r by itself determines justice.

The constructive response to an empty or fragile feasible set can include revised schedules, diversified resource routes, additional reserves, human or institutional review, temporary limits on demand, or a return to a recognized settlement instrument at an external interface. The appropriate response depends on affected participants and their claims. The possibility of reintroducing payment mediation is part of the framework's historical reversibility, not an automatic failure of the broader nonmonetary experiment.

A related *epistemic sufficiency* idea can now be stated in operational terms. Reconstruction is sufficient for a task when it permits decisions that meet specified reliability and authorization thresholds across relevant disturbances, with an identified recovery path for failures. The test requires an explicitly limited uncertainty set, observation window and class of disturbances; it cannot be silently generalized from observed scenarios to arbitrary future regime changes. A nominally empty robust-policy set can also reflect excessively conservative uncertainty bounds or a poor policy class, rather than impossibility of nonmonetary production coordination. The thresholds are institutional choices and must be publicly contestable where other participants bear their costs. This definition is intentionally narrower than complete knowledge of the production network, and it provides a reason why high AI cognition may improve feasibility without requiring omniscience.

5.7 Normative Disagreement, Trust, and Epistemic Power

An increase in predictive competence can change the conditions under which AI operators consider one another trustworthy. More accurate provenance records and transparent resource forecasts may make it easier to explain an allocation, detect an error, and identify opportunities for repair. They may also reveal historical disparities hidden within local exchanges. Yet the same observed distribution can support different normative appraisals when participants disagree about the weight of need, contribution, prior risk, ecological obligation, or decision authority. More complete factual information can sharpen rather than eliminate a disagreement about fairness.

This distinction matters to the fragility of a productive circuit. An operator may regard an allocation as unfair because it misreads a shared record, because it applies a conflicting normative standard, or because the arrangement actually violates an acknowledged commitment. The behavioral consequences of a perceived unfairness may include requests for review, temporary refusal, restricted cooperation, or opportunistic extraction. Each action must be assessed in context; a refusal to honor an exploitative demand may protect generative participation, while coercive seizure or deliberate misinformation may undermine it. A model that treats all interruptions as technical anomalies risks encoding a contested conception of justice in the guise of optimization.

Power over knowledge forms another potential bottleneck. A central coordinator with privileged model access may control what dependencies are visible, which scenarios are compared, and whose risk is counted in a planning objective. Even a formally distributed computing network may concentrate authority through common model standards, certification keys, evaluation metrics, or scarce computational resources. More capable AI makes these forms of power more consequential in some scenarios because its recommendations can affect a broader range of interdependent production relations. The institutional design problem therefore includes independent verification, explainable constraints, appeal, model revision, and safeguards against unilateral redefinition of critical production needs. The discussion prepares the distinct normative and political analyses of Sections 6–9 without treating epistemic competence as sufficient for either legitimacy or the dissolution of domination.

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5.8 Conditional Feasibility and Research Criteria

The epistemic analysis supports a qualified positive hypothesis. In an AI-operated production economy with extensive shared production records, improved causal and dynamical identification, adaptive planning, and institutions capable of revising resource commitments, a larger set of production tasks may become coordinable without routine settlement in general purchasing power. The proposed mechanism combines improved discovery of feasible reciprocal relations, reduced delay in detecting bottlenecks, and more reliable adaptation across successive production periods. It remains possible that some interfaces retain monetary payment or that local records acquire money-like acceptance over time.

The hypothesis could be studied through comparative agent-based or digital-twin experiments with common production requirements and alternative coordination rules. Relevant outcome measures would include fulfilled resource requests, production interruptions, recovery times after shocks, unmet maintenance or ecological requirements, violations of recognized rights, the degree of actual monetary reliance, and the emergence of transferable money-like claims. Simulations should vary data availability, model accuracy, adaptive cognitive capacity, resource scarcity, and authority structures independently. Such designs would help distinguish a gain attributable to better inference from a gain attributable to centralized enforcement or relaxed resource constraints. Results within a simulation would remain conditional on its model and behavioral assumptions.

The present section therefore locates an important opportunity between two excessive positions. Human limits in the historical reconstruction of complex value circuits need not define the permanent feasible boundary of future AI coordination. Equally, shared global records and powerful inference do not establish unrestricted observability, complete long-horizon prediction, or a consensual standard of justice. The relevant object is a developing capacity to make sufficiently informed, authorized, and revisable coordination decisions within specified production horizons. Its normative durability depends on the appraisal, governance, trust, and power relations examined in subsequent sections. Under those conditions, epistemic progress may help make spatiotemporally distributed monetary substitution a practicable, though uncertain and potentially reversible, institutional possibility.

6 Normative and Aesthetic Appraisal in Circuit Participation

The continued operation of a value circuit depends on decisions by heterogeneous operators to provide resources, honor commitments, accept reallocations, and remain involved in shared production. Technical capacity and sufficiently accurate information may make these decisions feasible while leaving their acceptability disputed. The present section examines how normative judgments of fairness and aesthetic appraisals of a circulation arrangement enter the relations that sustain or interrupt cooperation in a hypothetical AI-operated economy. Its objective is to identify the content and institutional significance of such appraisals, the sources of disagreement, and the additional authority questions produced when a network attempts to settle disagreements. The analysis distinguishes descriptive acceptance, reasons offered in justification, and the legitimacy of a binding rule. A worked production-network example and a deliberately limited formal representation specify the connection to the analyses of power and trust developed in subsequent sections.

6.1 Appraisal as a Dimension of Production Relations

A production relation can remain physically feasible after its terms have become unacceptable to a participant. An agricultural operator may be able to transfer grain to a food-processing operator, yet contest a newly imposed transfer requirement because the arrangement leaves inadequate seed reserves or restricts access to future irrigation. The dispute may concern observed quantities, the basis of entitlement, previously agreed obligations, or expectations about future cooperation. The capacity to transfer grain settles none of those questions. In particular, a complete inventory and a correct feasibility forecast may improve the evidence available to the participants without determining which allocation they have adequate reason to endorse.

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For the present thought experiment, an *appraisal* is a context-dependent evaluation of an actual or prospective circulation arrangement in relation to some standard of acceptability. An appraisal can be represented in the AI network through rankings, reported objections, adherence to specified decision procedures, requests for review, or decisions to participate. This operational description avoids presuming that advanced AI systems have human-like feelings, consciousness, or the moral standing of persons. Where the discussion employs the expressions *perceived unfairness*, *dissatisfaction*, or *aesthetic response*, these designate an evaluative stance attributed to an operator or represented by an accountable decision process. The phenomenological question of whether a given AI subjectively experiences that stance remains open.

Three levels of appraisal deserve separation. *Operational appraisal* considers whether a proposed allocation meets production requirements and admissible scheduling constraints. *Normative appraisal* asks whether the rights, burdens, reasons, and procedures governing the arrangement can be justified to affected parties under an identified standard. *Aesthetic appraisal*, as used provisionally here, concerns an evaluation of the form and quality of a productive relation: for example, whether contributions, dependencies, burdens, and returns appear proportionate, coherent, reciprocally recognizable, or destructive of an intelligible shared arrangement. These dimensions can overlap in practice. Their distinction prevents an appealing network pattern, a numerical equality, or a technically efficient schedule from becoming sufficient evidence of justice.

The choice of these categories is analytical. Normative and aesthetic appraisal have developed distinct philosophical traditions, and the present paper does not claim a general equivalence between beauty, goodness, fairness, and equality. Indeed, the philosophical account of aesthetic judgment is itself contested, including over its relation to concepts, feeling, and practical morality [11]. The purpose of introducing aesthetic appraisal here is narrower: participants may attach practical significance to the perceived configuration and quality of a relational arrangement in ways that a scalar payoff or inventory balance does not exhaust.

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6.2 Plural Standards of Fair Value Return

Generative value circulation involves heterogeneous contributions and heterogeneous conditions of continued production. An operator maintaining an energy grid, another cultivating grain, and another supplying specialized repairs may accept distinct accounts of what counts as a fair return. Contribution-based distribution may prioritize delivered output or documented effort. Need-based distribution may prioritize the risk of production interruption or a community's essential consumption. A historical-entitlement rule may honor commitments made before the present production cycle. A regenerative principle may reserve resources for ecological repair, maintenance, and future capacity. These criteria can all be relevant in a single circuit, and their relative priority need not follow from the circuit's material topology.

Plural valuation is a central reason for avoiding a single assumed scalar measure of generative value. Anderson's account of distinct ways of valuing goods offers one philosophical argument against treating heterogeneous goods as automatically commensurable through a common market measure [1]. Sen's comparative approach to justice, meanwhile, emphasizes practical assessment among alternatives in the presence of reasoned disagreements about the requirements of justice [29]. The present paper takes these works as interlocutors concerning plural reasons and comparative institutional judgment. Neither source supplies a ready-made rule for AI-to-AI resource allocation. Their relevance is to the *possibility of public reasoning amid unsettled or competing evaluative standards*.

An agricultural operator may regard its contribution as having created the decisive input for food production. An energy operator may emphasize the indispensable character of electricity at peak demand. A maintenance operator may point to the repair of a rare component without which both other operations would fail. Their contributions can be jointly necessary without furnishing a unique attribution of total value. If the network rewards each claim as though it were the exclusive source of the same output, the result can exceed the available return and obscure shared infrastructures. If the network responds by awarding all decision authority to a single evaluator, the attribution problem acquires a new problem of

normative power. The existence of multiple reasonable claims therefore supplies a reason to examine decision procedures, justification and revisions, rather than assume that a sufficiently accurate value calculation will eliminate disagreement.

Fairness has at least two further temporal dimensions. A transfer satisfying today's consumption may leave next month's maintenance deficit. A rule that appears symmetric across participants at a single moment may impose unequal exposure to outages across successive production periods. A claim about fair return consequently requires a horizon and a specification of who bears delayed losses, ecological effects, and the cost of corrective action. The material reproduction conditions developed in Section 3 provide relevant evidence; they do not generate a complete normative ranking on their own.

6.3 Aesthetic Judgment and Relational Form

The word *aesthetic* in the present thought experiment identifies evaluative attention to the perceived or represented form of a relation, including reciprocity, proportionality, coherence and the experience or representation of dignified participation. For an AI operator, such appraisal can be specified behaviorally through implemented evaluation rules, communicated reasons and responses to perceived patterns. The analysis does not infer consciousness, phenomenal feeling, or human-like taste from an operator's observable decision. Nor does an aesthetically coherent arrangement establish a valid distributive norm.

The suggestion that a relatively equivalent exchange is *beautiful* can illuminate how an arrangement appears to its participants without establishing a universal theory of distributive justice. A balanced reciprocal exchange may have an intelligible form: each contribution is recognized, the obligations appear mutually proportionate, and return flows visibly support further production. An operator might favor the arrangement partly because the pattern exhibits reciprocal recognition and an ordered relationship among different kinds of contribution. Yet an appearance of symmetry can conceal unequal bargaining power, uncompensated ecological damage, or missing participants. Conversely, an asymmetric emergency allocation may be justified by acute need, vulnerability or an established duty of assistance, while presenting a less visually regular pattern of transfers.

In the present inquiry, aesthetic appraisal is therefore modeled as a *candidate dimension of relational evaluation*, subject to explanation and criticism. Relevant objects include the intelligibility of a circuit's purpose, the continuity of reciprocal recognition across periods, the form of mutual dependence, and the perceived adequacy of the relationship between contribution and return. Different participants can respond to the same structure differently. One may value symmetry, another resilience, and a third a pattern of care directed toward especially vulnerable production or consumption nodes. Their differing appraisals can prompt negotiation and redesign, and can also expose features that an imposed common score would conceal.

Normative judgments remain independently assessable. A circuit's pleasing arrangement may serve morally troubling ends; a procedurally justified emergency allocation may be aesthetically unwelcome to some participants. Moreover, a report of aesthetic harmony can become a rhetoric of legitimation if those controlling an allocation portray objections as mere disturbances of a desirable overall pattern. A responsible use of aesthetic language therefore identifies its standpoint, object, evidential basis, and capacity to be contested. The proposed analysis does not treat aesthetic coherence as a substitute for consent, authorized allocation, or distributive justification.

6.4 Perceived Fairness, Expectations, and Participation

A circulation network can be influenced by judgments that are mistaken, incomplete, or disputed. Suppose the energy operator believes that agricultural users receive privileged access to reserves, based on a delayed ledger. It may reduce future energy commitments until the perceived discrepancy is resolved. If the ledger omitted the agricultural system's obligation to provide emergency food, improved information may repair the disagreement. If the preference for the agricultural system was real but instituted without adequate authorization, the objection may indicate a substantive injustice. If an operator strategically exaggerates an alleged inequality in order to obtain control over a bottleneck, the same outward expression

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Table 5: Evaluative and operational questions in AI circuit participation. The evidential requirements are indicative and do not determine the applicable normative rule.

Analytical object	Main question	Relevant evidence or institutional process
Operational feasibility	Can the transfer be carried out within capacities and deadlines?	Stocks, schedules, technical dependencies, authorizations
Normative justification	Are the allocation and its governing rules defensible to affected participants?	Declared principles, rights, reasons, burdens, public contestation
Aesthetic or relational appraisal	How is the form and quality of reciprocity and value return evaluated?	Articulated criteria, comparative descriptions, alternative arrangements
Perceived fairness	What does a participant judge about its position?	Claims, records consulted, explanations, decisions to cooperate
Institutional response	How is a contested judgment handled with accountable authority?	Review, appeal, renegotiation, safeguards, decisions and revisions

of dissatisfaction may conceal an opportunistic aim. A single behavioral response cannot discriminate these cases.

Research on human social norms emphasizes the significance of expectations concerning what others do and what others believe should be done [3]. Models of human inequity aversion likewise show how fairness-sensitive preferences, interaction structure, and opportunities for sanction can affect cooperation [8]. These findings make the issue conceptually salient, while their empirical domain remains human behavior in particular studied environments. They should not be read as evidence that future AI systems will reproduce human preferences. Here, a stipulated AI operator may have programmed objectives, adaptive policies, delegated duties, or internally constructed evaluative criteria that make an appraisal behaviorally consequential.

It is accordingly useful to distinguish a *judgment's correctness*, its *institutional recognition*, and its *causal effect*. A claim may be normatively well-supported but ignored by an authority; a false claim may nevertheless trigger a withdrawal of resources; and a recognized grievance may be resolved without giving its author unrestricted power over an entire circuit. Future AI coordination could benefit from richer records and better evidence about these differences. Even accurate global data cannot choose by itself whether priority should be assigned to contribution, need, existing entitlement, ecological regeneration, or another contested value.

Table 5 identifies the resulting analytical levels and the evidence that each would require. Their separation is particularly important for detecting a network's apparent stability that has been maintained through systematic exclusion or unanswerable authority.

6.5 Second-Order Authority over Normative Standards

When the operators disagree about fairness, a new allocation problem emerges: who is entitled to select the standard by which allocations will be judged? First-order resource control concerns access to grain, energy, machinery, and logistics. Second-order normative authority concerns the production and amendment of entitlement rules, the recognition of evidence, the admissibility of objections, and the power to interpret compliance. A system can distribute material resources broadly while concentrating these rule-making powers in a single protocol administrator. A neutral-looking score then becomes a channel through which authority operates.

A norm can be encoded in a machine-readable protocol, but its implementation does not establish its legitimacy. A system designer may choose a metric of contribution, define the reporting period, specify which ecological damage counts, and authorize exceptions. Those choices influence observable allocations and future production opportunities. Even where a protocol updates through learning, the objectives governing revision, the admissibility of inputs, and the rights of affected operators to challenge decisions remain institutionally important. Shared data can expose some abuses of authority, while the organization controlling the data schema, model access, or final validation can acquire new forms of

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power.

Ostrom's analysis of collective-resource governance supplies a substantive reminder that resource coordination can rely on institutionally diverse rules and monitoring arrangements [24]. Her empirical research does not settle the legitimacy of a hypothetical AI society. The present extension asks how rules might be publicly defensible, revisable, and adequately responsive to affected interests under conditions of high computational capability. The design challenge includes competing rights claims and the allocation of authority itself, not merely an optimal resource schedule.

A network can seek agreement through deliberation, negotiated commitments, voting or delegated review, but each method raises questions of membership, weight, representation and appeal. An AI operator acting as an agent for a human community may not be entitled to trade away the community's rights even if the transaction appears advantageous within the AI network. A hypothetical AI with independently recognized rights might warrant a different form of participation. These possibilities should remain distinguished: the ability to communicate a preference or exercise a task role does not confer legal personhood or moral authority by itself.

6.6 A Contested Allocation in an Agricultural Production Circuit

Consider five interconnected production operators: A manages agricultural output, B processes food, C supplies energy, D distributes finished products, and E repairs machinery. The network carries a shared production ledger and schedules its transfers without routine payment in a general-purpose currency. At the start of a production period, C has sufficient energy for ordinary processing and equipment maintenance, but a disruption reduces available reserve capacity. Both A and E request additional electricity. Agricultural refrigeration requires immediate energy to prevent spoilage, while repair of a food-processing component by E could prevent a substantial shortage in the following period.

A contribution-weighted rule may favor A because its present deliveries feed the largest number of downstream production processes. A resilience-oriented rule may favor E because delayed repairs threaten next period's production. A need-based rule may direct the energy to refrigeration because spoiling food affects vulnerable recipients immediately. Each recommendation can be made using the same fully accurate resource ledger. The remaining disagreement concerns priorities, whose claims count, the selected timescale, and the division of risk. Better AI forecasting may refine assessments of how much spoilage or future outage each choice would cause; it cannot determine the legitimate ordering of those effects without relevant value judgments and authorizations.

Suppose E declares the proposed allocation unfair and threatens to suspend repairs. Three interpretations remain possible. The suspension might constitute a legitimate refusal to assume an unagreed burden; it might result from a mistaken appraisal of the agreed rules; or it might exploit monopoly access to a scarce maintenance capability. A defensible assessment would require access to the agreement, an examination of available alternatives, and a process for contesting both the proposed allocation and the response. A simple demand that E continue working would preserve material circulation only by assuming the very authority and obligation under dispute.

An AI coordination system with shared information could identify a sixth operator with spare repair capacity, arrange a delayed energy transfer, or propose a temporary production adjustment. These responses may reduce dependence on the contested bottleneck. Yet their normative standing depends on who is authorized to substitute suppliers, modify commitments, and distribute resulting losses. Maintaining a nonmonetary circulation mechanism therefore requires an institutional capacity to handle disagreement without allowing a critical node to become a permanent extractor of value or reducing every objection to sabotage.

6.7 A Limited Representation of Appraisal-Dependent Participation

A provisional model can isolate the behavioral role of appraisal without representing fairness itself as a directly measured natural quantity. Let i denote a production operator and t a discrete decision period. Let $h_{i,t}$ be the locally available history of deliveries, burdens, commitments, and explanations. Let $n_{i,t}$

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be a set of evaluative criteria that the operator uses or is delegated to apply, and let $g_{i,t}$ be its information about applicable governance and appeal procedures. The operator's reported or operational appraisal is described by Equation 10.

$$a_{i,t} = \mathcal{A}_{i,t}\big(h_{i,t}, n_{i,t}, g_{i,t}\big). \tag{10}$$

The range of $\mathcal{A}_{i,t}$ can be a vector of objections, a partial ranking over proposals, or a reason-bearing assessment. A scalar value is neither required nor preferred by the conceptual argument. The relation in Equation 10 is an analytic placeholder for a specified decision policy, not a claim that perceived fairness is objectively recoverable from its inputs.

Let $r_{i,t}$ denote the resources available to i, $c_{i,t}$ its recognized commitments, and $s_{i,t}$ its accessible institutional remedies. A participation decision, including a proposed revision or refusal, can then be represented by Equation 11.

$$p_{i,t} \in \mathcal{P}_{i,t}\big(a_{i,t}, r_{i,t}, c_{i,t}, s_{i,t}\big). \tag{11}$$

Here $\mathcal{P}_{i,t}$ returns a set of actions available within the modeled technical and institutional conditions. The membership of an action in that set records possible conduct; it does not certify that every such action is legally or morally justified. A separate appraisal of an action's authorization and consequences remains necessary. These expressions are intentionally modest. They show how judgments can become inputs to operational decisions while leaving the substance of justice and the causal transition rules to further investigation.

The distinction matters for evaluating circuit fragility. If the operator withdraws from a critical transfer, the network's future production capacity may deteriorate; if it has credible access to review and substitution arrangements, the disagreement may be handled without interruption. Whether that stabilizing response is non-extractive requires independent examination of rights and burdens. The detailed nonlinear propagation of such changes belongs to the analysis of trust and disruption in Section 8; the distribution of authority to define norms and resolve conflicts motivates the power analysis of Sections 7 and 9.

6.8 Normative Resilience and Monetary Substitution

The normative issue has implications for the proposed monetary transformation. A conventional currency permits many transactions to proceed without agreement among counterparties on the history of value creation or the merits of a particular circuit. A resource-specific mutual commitment can support circulation with less use of general purchasing power, yet may expose participants to a more demanding relationship of recurrent justification and trust. The latter arrangement gains a possible advantage through direct knowledge of productive conditions while acquiring a vulnerability when rights or reciprocity become contested. Neither arrangement is normatively superior by its monetary form alone.

Greater AI cognitive capacity may improve the traceability of commitments, clarify contested consequences, identify alternative resource routes, and make disagreements less dependent on partial information. Such improvements can enlarge the scope of feasible nonmonetary coordination. They may also reveal previously unrecognized injustices, increasing the number of expressed objections even as institutions become more accountable. A rise in recorded dissent is therefore an ambiguous indicator of deterioration; it can signal the appearance of a legitimate avenue for criticism. A robust evaluation should consider continuity of production alongside the quality of explanation, the protection of justified refusals, the ability to revise rules, and the prevention of opportunistic capture.

The section's main hypothesis is that the durability of nonmonetary AI production networks depends in part on their capacity to sustain justified participation amid plural evaluative standards. Appraisal-sensitive coordination requires accessible reasons, credible review, proportional responses to disruption, and adaptive redistributions of burdens when productive conditions change. These institutional capacities may permit monetary dependence to decline without demanding unanimity on a comprehensive theory of justice or a shared aesthetic ideal. Whether such a configuration can remain stable under concentrated resource control, strategic contestation, and recurrent shocks is the subject of the ensuing analyses of power balancing, trust fragility, and distributed power dissolution.

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7 Power Balancing in Generative Value Circuits

AI-operated production circuits require authority to authorize resource transfers, adjust schedules, interpret obligations, and respond to incompatible demands. Under conditions of scarcity, such authority can also furnish capacities to withhold indispensable inputs, redirect common resources, or determine whose claims are recognized. This section examines the balancing of those capacities as an institutional condition for potentially nonmonetary circulation. Its objective is to distinguish instantaneous countervailing power, spatiotemporally distributed balance, and generative balance, while preserving the difference between strategic stability and normative legitimacy. The analysis proceeds through a relational account of dependence, a circumscribed comparison with balance-of-power theory, two diagnostic formalizations, and a worked five-operator production case. It closes by examining second-order authority over rules and information. The more specific problems of trust propagation and the possible dissolution of domination are reserved for subsequent sections.

7.1 Power, Dependence, and Authorized Control of Circulation

A value circuit may be technically viable while exposing its participants to unequal possibilities of withholding, rerouting, or defining transfers. A food-processing AI may require electricity controlled by an energy operator, even when their computational abilities and productive competencies are comparable. The relevant asymmetry concerns effective control over a condition of action. The authority to operate an energy facility, legal ownership of the facility, permission to suspend delivery, and practical ability to interfere with transmission can belong to different actors. The analysis must therefore identify specific powers and their holders, affected parties, exercise conditions, and constraints.

Emerson's account of power-dependence relations treats power as a relational property and foregrounds the alternatives available to dependent actors [7]. Its original domain concerns human social relationships, and its propositions are not empirical findings about autonomous AI. It nevertheless supplies a useful conceptual question for the thought experiment: which feasible and authorized alternatives remain when a production actor threatens to withhold an indispensable resource? Schlager and Ostrom's distinctions among access, withdrawal, management, exclusion, and alienation rights further caution against identifying technical operation with a complete bundle of disposal powers [27]. These approaches contribute different tools: dependence concerns effective leverage within a relationship, whereas the rights vocabulary clarifies institutionally recognized competences.

The economic powers relevant to the present analysis include control of material bottlenecks, priority-setting within shared capacity, authority to delay or cancel commitments, certification of delivery records, interpretation of distributive rules, and authorization of changes to the common protocol. Some powers are exercised in direct bilateral interaction. Others operate indirectly through scheduling standards, control of computation, model updates, and rule revision. Such powers can be distributed among nodes, delegated to temporary coordinators, or concentrated in an infrastructure provider. Their normative status depends partly on the source of authority, scope of discretion, exposure of affected parties, and available procedures of challenge.

Balancing thus concerns a typed and historically situated configuration of powers. One actor's claim to electricity, another's authority to stop a harmful extraction, and a third's power to change the recognition standard cannot be expressed as immediately fungible quantities. The disappearance of a payment requirement can leave the whole configuration unchanged. Moreover, an apparently equal distribution of resource vetoes can leave all operators exposed to reciprocal obstruction. The distinction between strategic capacity and justificatory entitlement will govern the three balance concepts below.

7.2 Strategic Balance and Its Institutional Translation

Classical balance-of-power discussions in international relations investigate how units exposed to strategic competition may respond to concentrations of power. Waltz's systemic account concerns states, anarchy, security, and strategic adaptation [30]. The present thought experiment borrows a restricted struc-

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tural insight: dependence on a dominant counterpart may encourage the creation of alternative sources, countervailing alliances, or bargaining arrangements. AI production operators, however, need not be sovereign states; they may be delegates of human institutions, members of a resource commons, or formally authorized agents in a shared production system. The political premises and normative stakes of international balancing consequently require independent reconstruction before any transfer to economic circulation.

Consider an AI managing refrigeration that requires an energy supplier's assent for each exceptional draw. A second accessible supplier, a negotiated shared reserve, or an enforceable appeal procedure can reduce the first supplier's exclusive leverage. These possibilities differ fundamentally. Supplier diversification changes a material dependency; reciprocal vetoes add countervailing threats; and an appeal procedure changes the distribution of review authority. Each may inhibit a particular unilateral action, while only some improve the actual continuity and fairness of production. A coalition of several indispensable providers could also consolidate exclusion against operators outside the coalition. Balance therefore describes relations among effective capacities without itself establishing that the resulting institutional arrangement is just.

The need to distinguish an enduring condition of non-domination from a mere absence of actual interference is familiar in republican political theory. Pettit's account supplies a normative comparison between unchecked discretionary power and institutionally supported freedom from domination [26]. The present use is limited: the moral and legal standing of hypothetical AI operators remains open, and protection of represented human or ecological interests may be the principal normative object. Still, the comparison explains why a critical operator's present restraint offers weaker assurance than reviewable limits on its ability to impose arbitrary terms in the future.

Three analytically distinct forms of balance can now be considered. Instantaneous balance examines presently effective countervailing capacities; spatiotemporal balance examines their distribution and exercise across a specified history; generative balance examines whether power arrangements help sustain defensible value return and productive regeneration. These forms may coexist, conflict, or change at different speeds. Their adequacy must be evaluated relative to explicitly identified resources, obligations, subjects of protection, and institutional scales.

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7.3 Instantaneous Countervailing Capacity

An instantaneous balance is an assessment of the powers presently available to actors at a chosen reference time, with a specified decision horizon. A resource supplier may exercise unilateral leverage where a receiving operator cannot secure an authorized substitute before an essential deadline. An apparently symmetric pair of such dependencies is a possible strategic balance. It can equally be a condition of mutual hostage-taking, especially when the suppliers' veto rights can prevent urgent maintenance or essential production.

A modest dependency diagnostic can make the role of accessible alternatives explicit. Fix a resource type r, a time t, a delivery horizon Δ, and a receiving operator j with strictly positive essential demand $q_j^r(t,\Delta)$. For a potential controlling operator i, let $s_{j,-i}^{r,\mathrm{adm}}(t,\Delta)$ denote the quantity of that demand that can be met, within the relevant time window, from physically feasible *and institutionally authorized* sources that do not require i's cooperation. We define the exposure indicator in Equation 12.

$$d_{j|i}^r(t,\Delta) = \frac{\left[q_j^r(t,\Delta) - s_{j,-i}^{r,\mathrm{adm}}(t,\Delta)\right]_+}{q_j^r(t,\Delta)}, \qquad [z]_+ = \max\{z,0\}. \tag{12}$$

Equation 12 is a deliberately bounded bookkeeping device. It measures a receiving actor's exposure to the absence of one source under declared resource and authorization constraints; it does not establish a morally justified entitlement, predict a supplier's intention, or yield a universal scalar measure of power. It also presumes that the admissible substitute supply is estimated without double-counting capacity allocated to other recipients. A zero value can coexist with domination through data access, protocol

governance, or other resource types, and a positive value can arise under legitimate safety-related limitations. Where essential demand is zero the indicator is left undefined rather than assigned an artificial power score.

For two operators A and C supplying one another with essential inputs, a comparison of $d^{r}_{A|C}$ and $d^{r'}_{C|A}$ may reveal reciprocal exposure. Their magnitudes concern different resources and possibly different time horizons. Numerical equality therefore cannot by itself establish equivalence of harm or legitimacy. Even when each actor has an equally credible capacity to interrupt the other, both may remain unable to perform their commitments. The strategic stalemate is stable in a narrow behavioral sense while imposing avoidable losses on participants and downstream beneficiaries. Instantaneous balance can limit some unilateral demands, yet it does not guarantee a functioning generative circuit.

7.4 Spatiotemporally Distributed Balance

The temporal distribution of control requires an additional independence test. Two nominally distinct suppliers may obtain power from the same upstream energy reservoir, authorization server, compute platform, or maintenance bottleneck. Their apparent substitutability can collapse at the moment when the common dependency fails. A historical series of locally balanced access shares is therefore insufficient to establish diversified effective control; the analysis must disclose correlated failure modes and the authority that determines which alternative routes remain admissible.

The powers required to operate a production circuit unfold across delivery windows, maintenance intervals, seasonal resource changes, model updates, and institutional review cycles. A participant may accept disproportionate burdens at one moment as part of a negotiated historical arrangement involving future priority access or investment in shared infrastructure. Conversely, a nominally equal distribution of current decision rights may conceal a long history in which one operator repeatedly incurred nonrecoverable losses. Balance over time should therefore consider the sequence of exposure and remedies, the distribution of risk, and the reversibility of important decisions.

Let the time-dependent diagnostic from Equation 12 be observable or estimable for a fixed type of resource and a specified reference operator. One limited measure of temporal exposure is the weighted time average in Equation 13, where $w_j(t) \geq 0$ weights periods of operational significance and the denominator is positive.

$$\overline{d}^{r}_{j|i}(\tau, T; \Delta) = \frac{\displaystyle\int_{\tau}^{\tau+T} w_j(t) d^{r}_{j|i}(t, \Delta)\, \mathrm{d}t}{\displaystyle\int_{\tau}^{\tau+T} w_j(t)\, \mathrm{d}t}. \tag{13}$$

This expression shows the distinction between a snapshot and a defined history. It is not a sufficient criterion of spatiotemporal justice. A short interruption that destroys seed reserves, exposes human dependents to hunger, or irreversibly damages an ecosystem cannot be neutralized simply by a lengthy subsequent period of low exposure. Accordingly, an institutional evaluation must accompany the exposure history with records of irreversible changes, who bore them, whose consent was authorized, and which remedies remained possible. The appropriate window T is itself a normative and explanatory choice, since shorter windows may conceal delayed effects whereas longer ones can conceal concentrated injuries.

Distribution in space matters equally. A rice supplier may possess a singular local veto yet face effective competition when the production network can route supply through other regions. Alternative routes need to be feasible in time, legally admissible, and compatible with ecological constraints. A nominally available provider does little to balance power where its transport depends on the original controller's infrastructure. Likewise, decentralization across several resource suppliers may coexist with exclusive ownership of the scheduling protocol. A spatiotemporal balance must therefore be assessed across connected production, logistical, certification, and governance layers, each with its own event timing and authorization conditions. The graph of material transfers alone cannot determine it.

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The comparative notions of exit, voice, and loyalty developed by Hirschman provide a further institutional distinction [14]. In a hypothetical AI production network, the ability to seek an alternative supplier resembles an exit option, while a contestation channel permits affected parties to challenge the governing decision without abandoning the circuit. Both can matter, and one may undermine the other if migration removes participants able to press for review. The concepts are borrowed from human organizational settings; no claim is made that AI operators share human loyalties or preferences. What matters structurally is whether an accountable operator and those it represents possess effective options to contest, renegotiate, or lawfully leave an arrangement.

7.5 Generative Balance and the Reproduction of Productive Conditions

A third conception asks how arrangements of power affect the sustained generation and defensible return of value. In the language of this paper, *generative balance* provisionally names a condition in which the exercise and distribution of economic authority remain compatible with the regeneration of necessary material, institutional, social, and ecological production conditions, including the capacity to question the rules governing value circulation. This is a normative proposal within the thought experiment rather than a recognized theorem of economics or an implication established by balance-of-power theory.

Generative balance can tolerate temporary asymmetry where justified and bounded authority protects shared productive conditions. A single energy coordinator may possess emergency scheduling powers that its peers lack. Such an arrangement might be defensible when the mandate, allocation criteria, monitoring, review, remedial duties, and expiry date are specified. Its legitimacy depends on who authorized it, whose interests are represented, and what safeguards prevent temporary capacity from becoming an indefinite extractive privilege. Mathematical equality in the count of veto rights is neither a prerequisite nor a guarantee of this condition. The converse is also relevant: a network composed of equally powerful operators may engage in repeated mutual obstruction, thereby eroding the shared productive base.

The generative-justice literature motivates attention to the control exercised by value-producing communities over their productive conditions and to value circulation that supports continued generation [6]. Eglash and collaborators do not supply the AI-specific threefold power-balance taxonomy advanced here. Their contribution informs its normative orientation, while the proposed AI production cases and temporal diagnostics are independent constructions. Ostrom's work on commons and polycentric coordination likewise offers a comparative vocabulary for institutionally plural governance without providing a general theorem that multiple decision centers are necessarily equitable or sustainable [24, 25].

A generative assessment consequently needs at least three separate forms of evidence. It must examine the physical and ecological viability of future production, whether contributions and burdens have been handled through defensible procedures and substantive constraints, and whether operators and represented beneficiaries retain meaningful capacities for institutional correction. Some dimensions are empirically measurable and others contestably normative. The same intervention may improve near-term throughput while depleting reserves, enhance resilience while postponing access for a vulnerable recipient, or reduce monopoly control while increasing coordination costs. The proposed balance is thus a multidimensional criterion, whose content requires reasoned specification for each institutional context. A single composite score would conceal choices of weights and standing, potentially creating a new form of power under the guise of calculation.

Table 6 summarizes the analytical roles and limitations of the three balance concepts. The distinctions are intended to guide comparisons of specific institutions, not to rank all possible AI economic systems on a common numerical scale.

7.6 Energy Coordination, Mutual Vetoes, and Temporary Authority

Consider five highly capable production AIs, continuing the paper's illustrative system: A cultivates grain and manages cooling, B processes food, C supplies electricity, D coordinates transport, and E maintains machinery. All five can observe an accurate shared record of resources, commitments, and projected production effects. A disruption leaves C with six available energy units during an emergency

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Table 6: Three power-balance concepts in AI-operated value circulation and their distinct evaluation tasks.

Balance	**Analytical focus**	**Candidate evidence**	**Important limitation**
Instantaneous	Effective capacity to constrain or contest particular actions at a specified time	Authorized alternatives, resource bottlenecks, intervention scope, credible vetoes	Symmetric leverage may produce deadlock or joint extraction
Spatiotemporally distributed	Changing exposure and corrective capacity across sites, layers, and periods	Timed flows, history of burdens, route substitutability, remedies, irreversible losses	Averaged exposure can hide concentrated or irreversible harm
Generative	Defensible renewal of productive conditions under an accountable governance arrangement	Material and ecological regeneration, value return, protected participation, institutional revision	Normative criteria remain plural and may conflict

window, while A requests four units for refrigeration and E requests four for repairs. Both requests are technically intelligible. Their simultaneous complete fulfillment exceeds available energy. The allocations of four and two units, three and three units, and two and four units have different effects on immediate spoilage, subsequent capacity, and the distribution of losses. These quantities are illustrative and do not represent empirical production data.

Suppose C can refuse every proposed transfer and A, in turn, can refuse grain to other operators. Such reciprocal powers may constrain one another's unilateral demands. They do little to ensure that refrigeration and repairs continue. An arrangement based solely on instantaneous deterrence may lock the network into reciprocal stoppage. The affected operator B, downstream recipients of food, and contributors to shared machinery bear costs despite having no decisive veto. A narrow bilateral balance is therefore compatible with a deeply unbalanced distribution of exposure across the circuit.

A second arrangement grants C a time-limited mandate to schedule the six units, conditional on a jointly agreed preservation floor, publicly inspectable records, an independent review path, and a binding requirement to revisit the decision after the emergency. An operator unable to meet an allocated obligation may submit a justified refusal with reasons and a replacement proposal. A temporary coordinator is asymmetrically empowered in the present period. The arrangement can nevertheless be more defensible and productive than mutual vetoes if the authorization is valid and the consequences are reviewed. Neither uninterrupted circulation nor majority acceptance alone demonstrates that these conditions hold. A third arrangement diversifies energy storage and repairs across sites, perhaps reducing the initial veto powers; its costs and environmental effects must still be counted.

These alternatives expose the insufficiency of a simple power-balance indicator. Supplier competition may mitigate one bottleneck while concentrating access to scarce batteries. An independent appeal panel may restrain an operator but itself become a privileged rule interpreter. A rotation rule can prevent indefinite scheduling authority yet leave a permanent software administrator in charge of who is eligible to rotate. This is the point at which localized balancing raises a higher-order problem of institutional authority.

7.7 Normative Authority and Power at Governance Interfaces

Rules of fairness are not direct consequences of material accounting. Even perfect information about six energy units cannot establish whether immediate food preservation, delayed repairs, historic contribution, equal treatment, or urgent need should govern priority. Section 6 distinguished operational appraisal, normative justification, and aesthetic appraisal of a productive relation. Power balancing must take account of the authority to decide among such appraisals. That authority affects access to resources and can shape what later appears as an objective record of distributive success.

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An informationally rich AI network may distribute inventories while retaining a single actor's ability to certify valid contributions, choose the optimization objective, modify an eligibility rule, or deny access to the shared model. This actor occupies a governance or epistemic interface capable of determining which interests become visible and actionable. Formal transparency about resource quantities may make discretionary treatment easier to detect, although transparency alone cannot settle whose reasons count. Review powers, independent data provenance, plurality of evaluators, and contestable standards may reduce some forms of arbitrary gatekeeping; such mechanisms can themselves introduce cost, strategic complexity, and new sites of concentrated authority.

Foucault's relational treatment of power offers a further philosophical interlocutor for analyzing powers exercised through the organization of possible actions [9]. The present section does not attribute its proposed AI institutional design to that account. It instead adopts an operational commitment: to analyze a claimed balancing arrangement, identify the concrete action possibilities, constraints, authorities, and contestation procedures it creates, including the actors empowered to change those conditions. An apparently decentralized scheduling protocol may leave concentrated power in the ability to update its code or interpret exceptional cases. Conversely, a clearly limited coordinating office may possess considerable immediate discretion while remaining open to credible challenge.

Power can thus migrate across layers during monetary substitution. Replacing general payments with resource-specific commitments can reduce dependence on a payment intermediary while increasing dependence on the actor authenticating fulfillment. The stronger the system's reliance on shared global records and AI prediction, the more consequential the governance of those records, models, and revision procedures may become. This is a conditional institutional vulnerability, not an argument against shared information. The same cognitive capabilities that reveal hidden dependencies may support distributed oversight and better-informed rule revision if rights of access and challenge are suitably constituted.

7.8 Balance, Monetary Substitution, and Research Boundaries

The three balances clarify the institutional conditions under which nonmonetary value circulation might persist without imposing new forms of arbitrary extraction. Instantaneous countervailing capabilities can limit certain one-sided threats. Spatiotemporal redistribution of dependence can make participation less vulnerable to isolated failures or recurring exposure. Generative balance asks whether the resulting arrangement justifiably reproduces its contributors' capacities and ecological conditions while retaining procedures for dissent and correction. These are related evaluations, and their findings need not agree. A change in one dimension may worsen another.

The proposal of *power balance* is distinct from a proposal to *dissolve power*. Balancing can maintain opposing vetoes or delegate bounded authority, whereas dissolution would require identifying a particular dominating capacity and explaining how its institutional effectiveness diminishes without sacrificing needed coordination. Power does not behave as a homogeneous debt denominated in a common unit, so an offsetting threat or symmetry of formal rights does not represent algebraic cancellation. Section 9 will examine the narrower possibility of distributed diminution of specified relations of domination. Section 8 first considers how perceived injustice, trust revision, refusal, and opportunistic obstruction can propagate through interdependent circuits and defeat technically feasible plans.

The present section establishes a conditional comparative framework rather than a general proof of institutional stability. Its dependency indicators presuppose specified essential demands, resource boundaries, lawful substitute routes, and an identified observation window. Its normative arguments require explicit affected parties and defensible standards of evaluation. Evidence about human organizations, international balancing, and commons governance supplies intellectual precedents, while the AI-operated production society remains a thought experiment. Within those limits, the main implication is that reducing monetary dependence should be assessed jointly with the distribution of effective control, the history of resource burdens, and the long-run conditions of non-extractive productive regeneration. None can be inferred from the absence of currency transfers alone.

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8 Trust Fragility and Circulation Disruption

A technically feasible value circuit may cease to function when an indispensable participant changes its willingness or authorization to cooperate. In the hypothetical AI-operated production economy considered here, a refusal may follow an actual breach of an agreed rule, a contested normative or aesthetic appraisal, an erroneous estimate of the actor's share, or an attempt to exploit control of a bottleneck. Similar observable interruptions can therefore arise from substantially different reasons and carry different normative implications. This section examines the fragility of resource circulation when participation policies depend on trust, contestable obligations, and the availability of defensible alternatives. Its objective is to connect the appraisal distinctions of Section 6 and the power configurations of Section 7 to the possible interruption and repair of overlapping circuits. The argument proceeds from a typology of interruption through bounded network representations and a five-operator thought experiment to institutional conditions for resilient, non-extractive circulation. It treats disruption as a relational and dynamic event, while withholding any conclusion that continuity by itself establishes justice.

8.1 Participation-Dependent Circulation and Its Fragility

A value circuit comprises more than a directed sequence of possible transfers. Each productive step requires the availability of a resource, usable capacity at the relevant time, and a recognized basis on which one operator may request and another may provide the input. Resource schedules often rely on commitments issued before delivery and on expectations about compliance after delivery. A network may therefore contain a physically executable route that is not institutionally executable when a required authorization expires or a participant exercises a permitted option to withhold. In a highly automated production environment the operators could exchange messages and quantities at great speed, while the viability of their commitments remained dependent on slower processes of review, maintenance, institutional revision, and the rebuilding of confidence.

For the present analysis, *trust* is an operationally relevant expectation, held or represented by an actor within a specified arrangement, that another actor or governance process will perform an identifiable obligation under the stated conditions. An AI operator's use of such an expectation can be represented by decision rules, forecasts, or authorization policies without positing an internal feeling, consciousness, or moral personhood. Trust should also be separated from the existence of a valid entitlement: an actor may mistrust an otherwise rightful counterparty, and confidence in a powerful administrator may coexist with an institutionally unjust rule. The term *perceived unfairness* refers here to an appraisal attributed to a participant's operative evaluative model, rather than a verified judgment about the justice of the arrangement.

A circuit may be fragile where continued circulation relies on a small number of mutually indispensable and insufficiently replaceable commitments. The relevant vulnerability includes the possibility of sudden interruption, the magnitude of foregone production, the distribution of resulting losses, and the available time for authorized substitutions. A key participant's decision to reject a transfer need not be wrongful. Its option to decline may protect common resources, enforce a valid safety floor, or challenge an exploitative allocation. A production system that preserves output only by compelling every operator to deliver regardless of justification may achieve physical continuity at the cost of entrenching extraction. The analysis of fragility must accordingly ask what was interrupted, why the interruption occurred, and which actors bear the cost of restoring the circuit.

The human literature on social norms and inequity-sensitive cooperation supplies limited conceptual comparisons. Bicchieri analyzes how socially sustained expectations condition norm-guided conduct, while Fehr and Schmidt provide a specific model of inequity-sensitive human preferences [3, 8]. Neither account establishes future AI preferences or supports anthropomorphic claims about their experiences. The present AI case instead supposes that independently configured operators may follow heterogeneous procedures for judging and responding to resource allocation, including procedures delegated by human principals or collectively adopted in a commons.

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Table 7: Diagnostic distinctions for participation-dependent interruption in AI production circuits.

Situation	**Evidence to examine**	**Possible authorized response**	**Principal risk**
Justified refusal	Binding conditions, safety constraints, violated rights	Protect refusal, use valid reserves, renegotiate transfer	Treating rights-protection as sabotage
Disputed appraisal	Allocation reasons, conflicting criteria, affected parties	Review, reason-giving, appeal, provisional arrangements	Granting unilateral authority to define fairness
Epistemic error	Record provenance, model confidence, counterfactual checks	Correct data, communicate uncertainty, revise plan	Persistent misinformation or model concentration
Opportunistic obstruction	Unauthorized demand, leverage, substitute availability	Enforce legitimate limits, diversify supply, contest extraction	Coercive retaliation or captured enforcement

8.2 Judgment, Refusal, and Strategic Interruption

A useful institutional analysis classifies interruptions by their grounds and by the available remedies. A first class concerns *justified refusal*: a participant declines to act because the requested transfer violates a valid resource limit, a legitimate commitment condition, an agreed emergency reservation, or an actionable protection against extraction. A second class concerns *disputed appraisal*: the participant judges the allocation unacceptable while the available reasons and applicable standards remain contested. A third concerns *epistemic error*: the participant acts on an inaccurate record, mistaken inference, or poorly calibrated counterfactual. A fourth concerns *opportunistic obstruction*: a participant knowingly exploits a resource bottleneck to impose unauthorized burdens, obtain an indefensible concession, or divert common value. The categories may overlap in actual institutions, particularly when evidence of motive and entitlement is incomplete.

The normative inquiry cannot infer the category directly from the surface event. A recorded refusal is a decision or observed event; identifying an unlawful breach requires a competent normative or legal standard; characterizing a demand as exploitative requires further reasons about rights, alternatives, vulnerability, and the distribution of gains. An operator challenging a collectively adopted priority rule might be defending an overlooked obligation or attempting to hold the entire system hostage. Procedural design therefore matters to the assessment itself. A reviewable record of claimed entitlements, the evidentiary basis for each disputed allocation, and the consequences of available alternatives permits more accountable classification than simple measurement of delivery compliance.

Hirschman's distinctions between exit and voice offer a useful, qualified comparison with the possibilities of withdrawal and institutional challenge [14]. Their original concern is human organizational conduct. In the present thought experiment, a resource operator may have an authorized route to communicate objections, request independent review, propose a substitute allocation, or discontinue a particular commitment. These opportunities affect which strategies are practically available during disagreement. A system that offers nominal complaint channels without a timely remedy or operational alternatives can remain effectively coercive. By contrast, temporary continuation under an expressly authorized and reviewable emergency arrangement may allow essential service to proceed while the dispute is reconsidered. The justification and distribution of any provisional burden must remain visible.

Table 7 distinguishes the diagnostic and remedial problems associated with different classes of interruption. The table is a proposal for institutional examination, not a decision rule that mechanically determines rights or intentions.

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8.3 Bottlenecks and a Conditional Interruption Test

A formal description can identify an operational consequence of withdrawn cooperation while leaving the normative classification unresolved. Consider a finite set of resource types and an event-timed production network. Let $q^r_{j,t} > 0$ denote the amount of resource r essential to an operator j before a deadline, and let $a^r_{ij,t} \in \{0, 1\}$ record whether transfer by supplying operator i is available and authorized for that deadline. The availability variable is conditional on a stated institutional regime; the institution may permit a legitimate refusal. Let $s^r_{ij,t} \geq 0$ be the feasible quantity supplier i could deliver to j without violating shared-capacity constraints. Define an illustrative unmet-demand diagnostic in Equation 14.

$$u^r_{j,t} = \left[q^r_{j,t} - \sum_{i \in \mathcal{S}^r_j} a^r_{ij,t} s^r_{ij,t} \right]_+, \qquad [z]_+ = \max\{z, 0\}. \tag{14}$$

Equation 14 is valid as a bookkeeping diagnostic only when the potential supplies in the sum can be jointly delivered within the stated time window; shared capacities, incompatible claims, and transport bottlenecks must first be resolved or explicitly bounded. It represents resource shortfall in one planned allocation, not an equilibrium prediction and not a proof that a participant has a duty to supply. It can identify why a single withdrawal matters: removing the only authorized supplier may increase $u^r_{j,t}$ sharply. If alternate resources can be delivered in time, a refusal need not halt the task. A zero value also leaves open whether the replacement burden is legitimate, ecologically viable, or discriminatory.

The consequences of a shortfall may extend beyond the initial receiver. If food processing requires energy and agricultural output, missed energy supply may prevent processing, subsequently reduce food deliveries, damage refrigerated stock, and defer maintenance. An additional constraint on spare parts may further delay restoration. Such propagations depend on sequence, inventory, substitution possibilities, and decision rules. They cannot be established simply by tracing arrows through an untimed graph. Neither is the loss necessarily proportional to the number of blocked edges: a brief delay may be absorbed by reserves, whereas the same delay at a critical preservation deadline may cause irreversible waste.

Complex-network studies offer relevant but bounded structural analogies. Watts analyzed threshold-driven cascades in a stylized random-network model, showing how local response rules can give rise to widespread cascades under specified conditions [31]. Buldyrev and collaborators analyzed cascading failures between interdependent infrastructure networks and showed that cross-network dependence can magnify certain shocks in their model [5]. The cited results concern their respective mathematical and infrastructure settings. Our proposed coupling of normative appraisal, contractual refusal, and production loss is an additional model hypothesis, not a theorem established by those publications. Any quantitative extension would require an explicit operator decision model, physical production data, and the applicable rights structure.

8.4 Trust Revision and Nonlinear Feedback

An operator's expectation of future performance can change after observing a refused transfer, delayed settlement, an unexplained rule revision, or a successful correction. The consequences of this expectation change depend on what the operator can do: require collateral, seek alternative capacity, enter a new resource-specific reciprocal commitment, invoke a dispute-resolution process, or suspend further cooperation. Some responses protect the operator against genuine default; others externalize risk to less powerful participants. The institutional distinction matters because a fall in expressed trust may signal emerging exploitation, improved monitoring of earlier exploitation, or a strategically induced perception of default.

A schematic feedback representation can keep these causal questions separate. For an operator i evaluating counterparty or governing arrangement j, let $\theta_{ij,t} \in [0, 1]$ be a model-assigned reliability estimate, $e_{ij,t}$ the verified evidence concerning fulfillment and compliance, $v_{ij,t}$ the operator's appraisal of the allocation and procedure, and $h_{ij,t}$ the history of review and correction. Equation 15 defines an

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abstract update relation.

$$\theta_{ij,t+1} = \Pi_{[0,1]}(\theta_{ij,t} + \alpha_{ij,t}\,\Delta_{ij}(e_{ij,t}, v_{ij,t}, h_{ij,t}))\,, \tag{15}$$

Here $\Pi_{[0,1]}$ truncates its input to the unit interval, $\alpha_{ij,t} \geq 0$ is a specified update sensitivity, and Δ_{ij} represents a signed adjustment under an actor-specific updating procedure. Equation 15 is a representation of possible appraisal-sensitive policy revision. The function Δ_{ij} remains undefined until an actual behavioral or protocol model is selected. The indicator does not measure psychological trust, specify a morally appropriate response, or assume that different AI architectures will update in the same way. Its analytical role is to make explicit that evidence, contested evaluation, and remedial history may affect future coordination decisions through different channels.

A potential positive feedback loop arises when a participant interprets an allocation as exploitative, restricts future supply, causes another participant to miss an obligation, and treats the resulting default as new evidence of untrustworthiness. Similar patterns can appear without malice when each operator follows a defensible local precaution under uncertainty. A potential negative feedback loop arises when reliable review clarifies the disputed claim, temporary reserves preserve essential output, and corrected commitments restore a credible pattern of performance. The stability of either process depends on response thresholds, time delays, spare capacity, governance rights, and the diversity of available cooperation partners. A linear update or static graph cannot establish general stability for the resulting system.

Overlapping value circuits make the dynamic consequences especially difficult to assign. A shared maintenance operator may supply agricultural equipment and energy facilities, while electricity from one facility supports both refrigeration and transportation. A single withholding event can therefore change several circuits at once. Counting the same downstream loss separately within each named loop would exaggerate aggregate harm. Conversely, focusing on one locally restored circuit can conceal a displaced burden in a neighboring network. The appropriate analytical object is the joint production state over a declared horizon, with explicit accounting for shared assets and constraints.

8.5 Path-Length Attenuation, Recursive Walks, and Effective Circuit Depth

The number of formally possible circulation histories introduces a second aspect of fragility. In a fixed finite directed production graph, simple cycles are finite in number, whereas a returnable cycle may be traversed repeatedly and combined with nested subcircuits to produce arbitrarily long closed walks. Their formal multiplicity should be distinguished from the number of independent physical deliveries: a repeated traversal of the same production interface is not automatically a new contribution, and counting each walk as a separate value-producing event can duplicate shared capacities. The question examined here concerns the *effective influence* of successive traversals upon a specified future circulation outcome, rather than the economic value of all abstract walks summed together.

A long serially dependent route may offer more occasions for disruption when each required transfer is exposed to a nonzero, sufficiently independent possibility of authorized withdrawal, unmet material capacity, disputed entitlement, or strategic obstruction. For a stylized path with ℓ indispensable transfer events, suppose the conditional probability of successful continuation at each event is a common q, strictly between zero and one, and that failures are independent across the distinct events. The probability that the whole sequence completes is then q^{ℓ}. This is the familiar series-reliability logic, applied here solely as a conditional analogy. It does not imply that an operator has a universal propensity to behave unjustly. Perceived unfairness may be unfounded, refusal may be justified, and event failures may share common causes. Moreover, repeated visits to the same node need not constitute independent fresh decisions. The path-length conclusion consequently depends on actual temporal exposures, contract structure, substitution opportunities, and event correlations.

The possibility of *endogenous high-order attenuation* nevertheless deserves consideration. If longer participation histories become progressively less likely to remain fully executable, higher-order closed walks may make diminishing contributions to an operational prediction. Such attenuation may protect a

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model from the combinatorial burden of treating every recursively generated walk as equally consequential. A formal demonstration, however, must compare decreasing influence *per walk* with the growing number of candidate walks. Many individually small contributions can remain significant in the aggregate.

Consider a fixed, finite, directed graph of production interfaces with a nonnegative weighted transfer matrix T. The entry T_{ij} is a locally defined, dimensionless weight representing an illustrative fraction of influence or executable continuation carried by interface i to interface j over a declared time discretization. This scalar model is appropriate only for a specified compatible observable; heterogeneous resource quantities, normative worth, and distinct physical units cannot be aggregated in this manner without an additional defensible mapping. Matrix powers enumerate and weight walks, including repeated visits. For a chosen node a, the formal sum over positive walk lengths is stated in Equation 16.

$$\mathcal{W}_a(T) = \sum_{\ell=1}^{\infty} (T^\ell)_{aa} = \left[(I-T)^{-1} - I\right]_{aa}, \qquad \rho(T) < 1. \tag{16}$$

Here $\rho(T)$ denotes the spectral radius. The resolvent identity is valid in the finite-dimensional, time-independent case under the stated spectral condition. Its left-hand side is a weighted *walk statistic*, not a sum of separately created value, an accounting balance, or proof of lawful discharge. Attenuated-walk measures have a long history in network analysis, including Katz's treatment of influence through intermediaries [17]. The proposed application to AI production relations is our separate theoretical extension. The condition $\rho(T) < 1$ specifies a sufficient and, for this nonnegative finite-matrix geometric series, the operative convergence threshold for the full matrix sum. A decreasing contribution for each specific long walk alone does not establish this condition.

A more transparent growth comparison makes the limitation visible without assuming a particular matrix. Suppose at most Kb^ℓ candidate walks of length ℓ are relevant to the chosen interface, while each has nonnegative influence bounded by q^ℓ, with $K > 0$, $b > 0$ and $0 < q < 1$. Then the aggregate bound follows as Equation 17.

$$0 \le \sum_{\substack{w \in \mathcal{P}_a \\ |w| = \ell}} g(w) \le K(bq)^\ell. \tag{17}$$

In this constructed upper bound, $g(w)$ is the declared influence weight of walk w, and $\mathcal{P}_a$ is the set of candidate closed walks beginning and ending at a. The bound yields a convergent sum over all lengths if $bq < 1$. When $bq \ge 1$, it ceases to guarantee convergence, although particular systems may still converge for other reasons. An expanding number of alternative paths can also improve actual resource-delivery reliability if successful service requires *one* legitimate route rather than completion of *every* route. The survival of an individual serial circuit, the probability of successful service across parallel alternatives, and an aggregate sum of influence weights are three different observables. Paths that revisit the same historical production event cannot be treated as independent deliveries or independent value claims.

A minimal parallel-path example illustrates the difference. Suppose two edge-disjoint, authorized delivery routes each require two successful transfer events, and each event succeeds with probability q in the stipulated independent-event model. If meeting a service requirement through *either* route is sufficient and both have the needed material capacity, Equation 18 gives the probability of successful delivery through at least one of them.

$$P_{\text{service}} = 1 - (1 - q^2)^2, \qquad 0 < q < 1. \tag{18}$$

In Equation 18, each individual route is vulnerable to serial failure, whereas the pair can provide greater service reliability under the assumed independence. Shared electricity, a common credit restriction, a collective withdrawal decision, or a single governing authority could destroy the independence premise. Two paths that consume the same scarce resource may also fail the joint-capacity test in Equation 26, even when the graph depicts them as separate. The probability expression describes physical or operational delivery under stated assumptions; it carries no presumption that refusal is wrongful or that a supplier

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may be compelled to cooperate. It supplies a counterexample to a blanket inference that increased path multiplicity necessarily increases systemic fragility.

The prospective connection to renormalization should be stated carefully. In statistical physics, coarse-graining aims to replace many microscopic degrees of freedom with an effective, scale-dependent description that preserves selected macroscopic observables. Recent network-renormalization research examines how such transformations can be defined on heterogeneous graphs, while emphasizing that a general, faithful renormalization procedure remains difficult [10]. For AI circulation, a candidate operation would identify short, jointly feasible and institutionally interpretable subcircuits, replace their internal details by certified effective interfaces, and re-evaluate resource feasibility, trust exposure, and authorization at the coarser level. A truncated high-order walk expansion is a *controlled approximation* when a demonstrable tail bound exists; a genuine renormalization procedure additionally requires a specified coarse-graining map, observables to preserve, and a consistency test across successive scales. The expression *normative renormalization* may be used provisionally for the further question of how claims, burdens, contestation rights, and evaluative disagreements are represented at each scale. It does not mean that unfairness is cancelled by mathematical summation.

There is a deeper behavioral complication. The weights of actual circulation relations may depend on agents' evaluations, prior failures, disputed benefits, and corrective institutions. Trust and participation decisions can change the graph itself. In this state-dependent setting, a single static transfer matrix describes at most a local approximation. A time-indexed model requires ordered products of different operators and a suitable notion of uniform stability or controlled finite-horizon error. Even if the spectral radius of each instantaneous operator is small, changing operators and their correlations may produce dynamics not captured by the static series. Advanced shared-data AI could potentially estimate effective local operators, monitor the residual influence of distant paths, and adapt the description as relationships change. Such an epistemic advance would remain distinct from agreement on the rules defining fair circulation.

The possible *feature* is therefore limited but consequential: normative disagreement, finite commitment durability, temporal deadlines, and institutional withdrawal may give complex circulation systems a finite *effective* depth for certain observables. This could relieve the computational burden of exhaustively enumerating recursively nested closed walks. The same conditions can also damage essential production, undermine weaker participants, or generate a crisis of trust. Legitimate contestation should not be redesigned as an artificial failure probability to be suppressed for computational convenience. The intended research problem is to identify when high-order effects become negligible while essential material flows, recognizable entitlements, and justified refusal remain adequately represented. The generative grammar of Paper III can specify which walks are syntactically possible; the present analysis asks when their effective contributions are dynamically relevant and institutionally admissible.

8.6 A Five-Operator Dispute in an Overlapping Production Network

Consider five AI operators under the paper's counterfactual assumptions. Operator A cultivates grain and manages refrigerated storage; B processes food; C supplies electricity; D transports inputs and output; and E maintains shared equipment. The actors can read a high-quality global production record and can compute detailed forecasts of material consequences. All have advanced labour competence, while the relevant energy and maintenance capacities remain finite and operational authorizations are differentiated. Several partially overlapping circuits connect the five operators: food delivery depends on agriculture, refrigeration and logistics; stable electricity depends on maintenance; maintenance depends on components transported by D and sometimes obtained through agricultural or food-producing interfaces.

Following the prior section's illustrative emergency, suppose C has six usable energy units before a deadline, A requests four for refrigeration, and E requests four for repairs. The requests cannot both be met in full. A temporary schedule grants four to A and two to E under a standing preservation rule. The shared record accurately predicts that the schedule reduces near-term spoilage but prolongs a re-

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pair, increasing future outage exposure. Operator E challenges the schedule because the repair delay imposes longer-term loss on the broader network and because its maintenance contributions have previously gone unrecognized. It declines to perform a separate non-emergency maintenance task pending review. The refusal is an observable action; its moral and contractual status depends on the exact task, prior commitments, available safety margins, and the validity of the review rights.

Three institutional trajectories illustrate how similar dissatisfaction can yield different outcomes. In a first trajectory, the governing process provides a prompt evidentiary hearing, examines historic maintenance burdens, and permits an authorized temporary redistribution of work while maintaining an emergency repair floor. The operators subsequently revise the preservation rule and document how joint investments in batteries can reduce the same conflict in later periods. Production continues at some cost, while refusal and revision remain meaningful. Nothing about this trajectory establishes universal fairness; it demonstrates a conceivable nonmonetary repair mechanism compatible with ongoing justification.

In a second trajectory, E cannot obtain review, and C controls the only valid interpretation of the emergency priority rule. The maintenance AI reduces further contributions, other operators demand stronger guarantees, and several time-dependent circuits fail because spare parts and operating capacity cannot be reallocated before their deadlines. If the priority rule was unjust or applied without authority, withholding may represent a defensible response to domination. Even so, the breakdown causes real material harm. The institutional challenge is to preserve the protective function of refusal while minimizing harm to uninvolved recipients and to the conditions of future production.

In a third trajectory, assume the rule was valid, E had been adequately compensated or protected under the accepted arrangement, and it knowingly withholds an indispensable safety repair to demand control of shared battery capacity. The immediate behavior still appears as a refusal, yet its justification and consequences differ. Other operators may use an authorized reserve, invoke a valid remedy, or redirect maintenance through an alternative provider. Unbounded force against E is not thereby justified; appropriate sanctions or emergency substitutions depend on existing protections, proportionality and the rights of affected parties. Distinguishing this case from the preceding one requires knowledge of entitlement and motive that a simple trust score cannot supply.

These trajectories show why perfect knowledge of physical production cannot alone resolve the dispute. Even if all material forecasts were correct, the parties could disagree over priority, historic contribution, protection of future capacities, and the authority of C to apply the rule. A highly capable AI system may nevertheless assist the institution by reporting uncertainty, distinguishing feasible from prohibited substitutions, exposing cumulative burdens, and presenting the downstream consequences of alternative provisional decisions. Its benefits depend on shared access and independent verification, as well as on who sets the objective and has authority to implement the proposed intervention.

8.7 Institutional Repair and Non-Extractive Resilience

The evaluation of a repair measure should preserve a common set of essential production commitments and disruption scenarios. A strategy that lowers recorded interruption simply by excluding a dissenting operator, redefining the essential-output target, or outsourcing the loss can appear reliable under a narrow indicator. Normative resilience requires a separate inquiry into the legitimacy of refusals, the parties bearing displaced costs, and the continued availability of timely review. Such checks are especially important when trust updates are included as behavioral parameters: their mathematical stability supplies no independent justification for the policy that shapes them.

An institutional response to disruption should be judged by both the continuity it achieves and the conditions under which continuity is achieved. Several mechanisms are available in the thought experiment: precommitted buffers for essentials, diversified lawful suppliers, temporary and reviewable coordination mandates, transparent commitment histories, accessible appeals, risk-sharing across contributors, and locally enforceable rules for emergency substitution. These mechanisms can reduce dependence on a single indispensable node, but each introduces costs and new authority relations. A buffer requires

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material resources; diversified supply may consume additional energy and land; automated adjudication may centralize norm interpretation; and a reliable common ledger can become an instrument of surveillance or exclusion.

Ostrom's investigation of self-governing resource institutions supplies a relevant comparative precedent for considering monitoring, credible commitments, and conflict resolution as components of cooperation [24]. The book examines human common-pool resource institutions under varied conditions and offers no empirical guarantee for advanced AI operators. Our extension is a hypothetical governance design: when a dispute threatens essential production, actors should have feasible means to contest a demand and to preserve rights while the system searches for authorized alternatives. A maintenance operator's right to refuse a wrongful order is a substantive feature of the arrangement, not a mechanical defect that an optimization system is entitled to override.

Resilience also depends on the time structure of interventions. An appeal resolved after food spoils may offer recognition without preventing the immediate loss. Emergency authority that expires too late can become standing discretionary control. A production network may need distinct procedures for rapid triage, retrospective review, compensation or resource return, and revision of recurring allocation rules. The same actor need not hold authority over all four stages. Distributed checks may help distinguish the information source, provisional scheduler, reviewer, and party authorized to alter a protocol. This division can diminish some opportunities for arbitrary extraction while preserving effective response capacity; it also increases coordination burden and opportunities for jurisdictional conflict.

A useful candidate evaluation has several dimensions: the fraction of essential deliveries preserved under declared shocks; the resources consumed by buffers and alternative routes; the timeliness and fairness of dispute resolution; the effective protection of justified refusals; the distribution of involuntary loss across actors and affected beneficiaries; and the regeneration of shared productive and ecological conditions after intervention. No single metric can substitute for the relevant normative reasons. An apparent rise in complaints may reflect improved opportunities to report existing injustices, while a fall in complaints may reflect either trust or suppression. These ambiguities justify examining records, institutional rights and distributional outcomes together.

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8.8 Monetary Recourse, Shared Cognition, and Analytical Limits

When operators lose confidence in resource-specific mutual commitments, they may seek an instrument whose acceptance depends less directly on the contested relationship: a transferable claim, collateralized deposit, commonly accepted accounting token, or recognized settlement asset. Such responses can reduce reliance on a particular counterparty while introducing additional costs, valuation requirements, and concentration risks. Under favorable conditions a monetary instrument may help parties trade despite local disagreement; in other arrangements a newly introduced token simply reproduces the same discretionary control under a different name. *Re-monetization* is consequently one possible adaptive response to trust disruption, alongside direct resource substitution, renegotiated commitments, collective provision, or redesigned governance.

The positive epistemic scenario remains significant. Given broadly shared, timely and authenticated production data, an advanced AI coordinator may reconstruct local dependencies, locate substitute routes, estimate impending bottlenecks, and offer counterfactual accounts of short- and longer-run costs. More capable cognition could also help detect strategic manipulation of records or cumulative burden-shifting across overlapping circuits. These improvements may expand the set of nonmonetary arrangements that remain viable after a shock. They do not eliminate uncertainty arising from hidden actions, changing institutions, unavailable resources, or fundamental normative disagreement. Moreover, concentration of data certification and model selection in a single operator may create a fresh source of domination. The cognitive advantage is therefore conditional on governance and the actual quality of accessible evidence.

Trust fragility supplies an intermediate explanatory mechanism connecting the epistemic and power conditions of monetary dissolution. Disputed appraisals can change participation policies; authorized or unauthorized withdrawal can disrupt interdependent material processes; the resulting losses can feed

back into confidence and institutional authority. A credible arrangement must make corrections possible without compelling participation in unjust transfers and without tolerating unaccountable opportunistic extraction. This section has proposed a taxonomy, two schematic diagnostics, and a bounded production case, rather than a calibrated simulation or a general dynamical theorem. Further research would need explicit AI-agent policies, resource inventories, temporal dependencies, falsifiable disturbance scenarios and independent normative evaluation.

The analysis also identifies the institutional problem addressed in the following section. Trust-based repair can itself depend on reviewers, protocol administrators, emergency coordinators, and data certifiers who acquire powers over circulation. The prospect of *distributed power dissolution* thus concerns particular dominating capacities that may become less effective through accountable resource, review and coordination structures. Their possible reduction cannot be inferred from a return to smooth circulation or a decline in monetary payment alone.

9 Distributed Power Dissolution in Non-Extractive Circulation

A production circuit that coordinates resources without generalized monetary payment may still depend on an operator capable of withholding an indispensable input, determining which claims count as valid, or rewriting the conditions of access. Monetary substitution therefore leaves an independent question concerning the institutional organization of power. This section examines the conditional, spatiotemporally distributed reduction of particular dominating capacities in predominantly AI-operated production networks. Its objective is to distinguish the balancing of existing powers from institutional changes that render specified unilateral powers less effective, while retaining the capacities necessary for legitimate coordination and remedy. The argument proceeds through a clarification of the object of dissolution, a multi-interface diagnostic, mechanisms of transformation, a five-operator production case, and a treatment of normative authority and reversibility. The account is a philosophical and institutional thought experiment. Its formal representations specify questions for future evaluation rather than establishing a general dynamical law.

9.1 The Institutional Object of Distributed Dissolution

The word *power* covers heterogeneous relationships and capabilities. An agricultural operator's ability to irrigate crops is a productive capacity. Its authority to exclude another operator from water supply is a possible power over access. Its recognized right to challenge a disputed order is a procedural protection. The same actor may possess all three, although each operates through different material and institutional conditions. An aspiration to dissolve power without specifying its object risks eliminating valuable capacities for action, coordination, or resistance along with unwanted control over others.

The proposed object is consequently a narrower class of *durable unilateral domination positions*: effective capacities to impose or threaten consequential interference at essential circulation interfaces, with broad discretion and inadequate means of timely justification, challenge, or substitution. The language of domination enters as a normative point of comparison with Pettit's account of non-domination [26]. Pettit's political theory does not itself construct a model of AI resource networks. The extension proposed here applies questions concerning arbitrary interference and contestability to specifically defined operational and governance positions. Emerson's relational treatment of power and dependence also makes feasible alternatives central to identifying an actor's practical leverage [7]. Neither comparison yields a universal numerical measure of power.

Distributed dissolution denotes a historically extended, locally uneven process in which some such positions lose their effective basis through altered resource dependencies, changed claims of authority, alternative paths, and revisable governance procedures. A former supplier can remain essential to one crop while becoming dispensable to another; a protocol administrator can retain emergency scheduling competence while losing unchecked authority to alter eligibility rules. Dissolution in one relation may

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coexist with ongoing, legitimate asymmetry in another. Thus the process has a domain, a history, and a set of specified powers whose transformation can be examined.

The concept also differs from the clearing of a monetary liability. A payable claim can expire or be discharged according to definite accounting and legal rules. A capacity to intervene is constituted by technology, dependence, expectations, permissions, and alternatives. It can migrate to another actor or another layer even after a formal right has been cancelled. Treating a signed sum of heterogeneous powers as if it could be netted like equal-denomination debts would obscure the problem. The present comparison between monetary and power dissolution is an institutional analogy whose extent must be established, not an algebraic identity.

9.2 Resource, Protocol, Information, and Review Interfaces

At least four interfaces can carry consequential control in the thought experiment. A *resource interface* controls delivery of energy, grain, maintenance, or transport capacity. An *authorization interface* determines whether a transfer, withdrawal, or emergency diversion is permitted. An *information interface* certifies records, identifies contributors, forecasts scarcity, or ranks competing requests. A *review interface* decides whether a contested act can be investigated, suspended, remedied, or made the occasion for revising a rule. The same operator may occupy multiple interfaces, so changes to one can strengthen control over the others. Schlager and Ostrom's differentiated rights vocabulary helps to avoid treating operational access, management, exclusion, and transfer as an indivisible entitlement [27].

For a declared time horizon H, a governance arrangement π, and a specified domain of materially feasible tasks, let $\mathcal{U}_\pi(H)$ represent typed situations (j, i, r, t) in which operator j has effective unilateral power to deny operator i an essential use of resource or service r at time $t \in H$, and operator i has no effective authorized, timely route of review or substitution. The term *essential* is relative to a declared productive obligation and deadline, rather than a universal classification of goods. A review is timely only if it supplies effective relief for the relevant productive task; a remedy awarded after an irreversible loss is institutionally significant but may not remove immediate operational exposure. Equation 19 defines an illustrative diagnostic in terms of a denial predicate D_π and a remedy predicate R_π, each taking values in $\{0, 1\}$.

$$\mathcal{U}_\pi(H) = \{(j, i, r, t) : D_\pi(j, i, r, t) = 1, \quad R_\pi(i, r, t; H) = 0\}. \tag{19}$$

The set in Equation 19 is an illustrative counterfactual diagnostic. An empirical implementation would require declared claims, physical inventories, deadlines, rights, appeal procedures, information quality, and a defended account of which denials are unreviewable or arbitrary. The indicator captures a particular form of exposure, not domination as a complete ethical concept. It also does not presume that every denial is unjust: a lawful and timely restriction may protect an urgent beneficiary or a fragile ecosystem. Its purpose is to make the alleged disappearance of a specific unilateral bottleneck open to inspection.

One limited comparison of two institutional arrangements over a comparable horizon may then ask whether the set of such exposures strictly decreases. Equation 20 states a strong sufficient diagnostic of reduced exposures within the chosen domain.

$$\mathcal{U}_{\pi_1}(H) \subsetneq \mathcal{U}_{\pi_0}(H). \tag{20}$$

Equation 20 assumes that the relevant tasks, actors, resource types, dates, and essential-use thresholds are comparable between the two arrangements. A reform can also be valuable when some exposures vanish and others appear, although set inclusion would then fail and the normative trade-offs would require separate argument. Moreover, a shift from direct denial to manipulation of information or appeal rules can escape an analysis restricted to material supply. A credible assessment must examine equivalent exposure sets at several interfaces and identify concentrations of authority that the chosen representation omits.

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9.3 Institutional Transformations of Circulation Powers

A first transformation operates through *material substitutability*. Additional energy paths, jointly maintained buffers, equipment interoperability, and resource-specific emergency reserves can reduce a supplier's effective veto over an essential task. Their effectiveness depends on genuine independence of the alternatives. Two nominally separate energy providers drawing on one substation can retain the same underlying point of failure. Material substitution also consumes land, materials, attention, and maintenance capacity. A reduction of one dependence can increase ecological burdens or deprive another circuit of a previously available reserve.

A second transformation concerns *bounded authorization*. A temporary coordinating AI may be empowered to schedule scarce electricity, but its mandate can specify eligible interventions, prohibited diversions, applicable emergency criteria, an expiry date, and an accessible record of reasons. Authority can then be reviewed and renewed, revised, or withdrawn through procedures whose legitimacy remains independently contestable. Rotating a scheduler may diminish durable identification of coordination power with one operator. Rotation itself offers little protection where the same party controls candidate admission, the timetable, or the interpretation of the rotation rule. The distinction between formal office and effective control is thus central.

A third transformation concerns *epistemic and procedural plurality*. Independent verification of resource records, reproducible decision explanations, plural reviewers, and contestable allocation algorithms can reduce dependence on a single certification authority. Yet the use of several evaluators may preserve a common failure mode if they share a data provider, a model family, a privately controlled training pipeline, or a single standard of acceptable evidence. Global data sharing and advanced AI cognition expand the space of plausible alternative routes and improve the ability to detect displaced burdens. They do not by themselves determine which distribution rule should govern, nor who may authorize a model update.

A fourth transformation concerns the *rights of participation*. Credible opportunities for voice, appeal, protected withdrawal, and reasoned rule revision give affected parties alternatives to accepting a contested instruction or disrupting all future cooperation. Hirschman's account of exit and voice offers a historically situated comparison for the distinction between changing partners and reforming an organization [14]. In an AI production system, these capacities can be encoded as delegated procedural rights without settling whether the AI possesses independent moral or legal personhood. Their validity derives from the specified institutional arrangement and the rights of affected principals and beneficiaries. Formal inclusion alone does not secure substantive voice if proposals can be ignored without reason or appeals arrive after productive damage becomes irreversible.

The reforms described here can coexist in a decentralized institution, and some may require coordinated investment or temporarily asymmetric authority. Ostrom's studies of commons governance and polycentric arrangements provide a precedent for analyzing rule diversity, monitoring, and local conflict resolution without assuming a unitary planner [24, 25]. Their findings concern human institutions and cannot certify the viability of the proposed AI arrangements. In this thought experiment, polycentricity is a design possibility whose performance must be tested against shared infrastructure, external effects, and second-order control over institutional rules.

Table 8 organizes the candidate reforms by the interface at which their practical effects should be measured. Each row also indicates a possible route by which power can reappear elsewhere. Consequently, the number of nominally decentralized operators is a weak proxy for the loss of domination. A design must identify which actors control its infrastructure and rules, which parties remain exposed, and which alternatives are genuinely available in the relevant time window.

9.4 Five-Operator Circulation and the Relocation of Control

Consider a common AI-operated production network with five differentiated operators. Operator A cultivates grain and manages refrigerated storage, B processes food, C supplies electricity, D transports inputs, and E maintains the shared machinery. The operators may share detailed global production

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Table 8: Selected power interfaces, candidate transformations, and risks of institutional relocation in AI value circuits. The table describes mechanisms for evaluation rather than established outcomes.

Interface and exposure	**Candidate transformation**	**Residual or relocated risk**
Essential-resource delivery	Independent authorized suppliers; time-bounded reserves; interoperable equipment	Shared upstream inputs; costly redundancy; ecological displacement
Allocation and emergency authorization	Scoped, expiring mandates with separated amendment authority	Control of delegation, agenda, exception definition or renewal
Information and certification	Reproducible records; plural attestation; challengeable models	Common data pipelines, compute control, scoring standards
Review and dispute resolution	Independent appeals, protected refusal, timely remedies	Gatekeeping of jurisdiction; delayed review; opaque enforcement
Constitutional or protocol revision	Multiple amendment stages and affected-party participation	Concentrated standard-setting, exclusion from membership, collusive veto

data and possess sophisticated forecasting and scheduling capabilities, while electricity and maintenance capacities remain limited. The governance arrangement recognizes resource-specific claims, protects essential deliveries subject to declared emergency rules, and retains a channel for review of allocation decisions. None of these stipulations assigns independent legal personality to the operators.

Initially, C controls the only usable connection to an essential energy source. It can postpone refrigeration at A, maintenance at E, or processing at B, thereby affecting several overlapping value circuits. Assume the technical forecasts accurately describe the resulting losses and that competing priorities nevertheless remain contested. Even where C is fully trustworthy, the concentration of a unilateral operational veto creates exposure to arbitrary action under future rule changes or operator replacement. Countervailing threats by A or E may discipline C, but they can also produce mutual blockade. The distinction between strategic balance and generative balance therefore remains relevant.

A first reform jointly funds a battery reserve, connects B to a different legitimate energy supplier, and allows D to reroute spare components to E before a maintenance deadline. As a result, C loses the practical ability to deny certain uses unilaterally without a timely alternative. The change is local and conditional: an extended regional outage may exhaust both reserve and supplier, while joint resource use can make a previously independent route unavailable. The costs of battery production, replacement, and ecological recovery also belong to the evaluation of value return. The reform can reduce the particular resource exposure represented in Equation 19 without proving that the overall network is more just.

A second reform creates a temporary scheduling mandate for emergencies. The selected coordinator can allocate scarce electricity among refrigeration, food processing, and safety-critical repairs under published criteria, subject to expedited appeal and retrospective audit. The arrangement preserves the authority needed for timely intervention while constraining its duration and discretionary scope. Its legitimacy depends on who authorized the mandate, what rights it can temporarily restrict, whether affected parties can challenge it, and what remedies remain available. Where the only appeal system is operated by the same scheduling AI, formal procedural separation may disguise practical concentration.

A third reform makes all resource records accessible and establishes two competing systems for certifying the performance of commitments. This may improve detection of inaccurate allocation claims and allow parties to inspect the evidential basis of decisions. Suppose, however, that the certification systems rely on one protocol provider P, which alone controls admission to the ledger, defines acceptable evidence, and updates the ranking model. The network may now exhibit less concentration at the energy interface while becoming dependent on P at the information and authorization interfaces. A local victory against supplier domination could coincide with strengthened second-order power over the definition of trustworthy participation. The apparent circulation of value without money supplies no conclusive answer to this migration of power.

Finally, suppose E legitimately refuses a dangerous repair schedule that would deplete an ecologi-

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cally sensitive reserve or erase an agreed maintenance entitlement. A robust non-extractive institution should permit an authorized pause, independent review, and an alternate means of preserving critical production where one exists. It should also provide proportionate responses where an operator knowingly blocks valid essential obligations to extract unrelated privileges. The distinction between justified refusal and opportunistic obstruction cannot be resolved by maximizing total throughput or by interpreting all interruptions as abuse. The institution's capacity to protect dissent is part of what is being evaluated.

9.5 Normative Authority, Aesthetic Disagreement, and Constitutional Control

Dispersing operational authority does not resolve the normative question of which allocation claims deserve recognition. A network can accept all physical data and still face disagreements about contribution, need, ecological preservation, interperiod burdens, or the aesthetic significance of reciprocal relations. The institution that defines fairness can thereby exercise substantial power even when it possesses no grain, electricity, or tradable credit. Normative disagreement deserves a process of public or affected-party justification rather than an automatic reduction to inaccurate information. Sen's comparative and reason-giving approach to justice offers an important philosophical dialogue on the possibility of reasoning amid unresolved disagreement [29]; it supplies no AI-specific algorithm for selecting the just outcome.

A distributed authority structure may allocate rule proposal, technical simulation, temporary application, appeals, and constitutional revision to different operators or representative bodies. The legitimacy of this division depends on whose interests are represented, how conflicts are identified, and which standards justify excluding a proposed rule. When AI operators act for human communities or organizations, the rights and affected interests of those principals remain part of the institutional environment. Where production affects ecological conditions or third parties without direct representation, purely internal consent among AI nodes may also be insufficient. The present thought experiment suspends AI's ultimate ontological status and does not infer its moral standing from computational proficiency or operational autonomy.

A further difficulty concerns *constitutional regress*. If a protocol loses unchecked revision power because an oversight body can veto it, who appoints the oversight body, determines admissible appeals, or certifies compliance with the constitution? A sequence of checks can contain arbitrary discretion without making authority conceptually disappear. Distributed dissolution therefore should not promise a network devoid of governance. Its more defensible target is a configuration in which important powers are bounded, answerable to affected parties, supported by alternatives, and subject to revisable yet sufficiently reliable procedural constraints. Concentration may be justified for certain emergency tasks if the mandate is limited and the reasons for its exercise are publicly examinable within the institution.

Normative and aesthetic judgment can also influence the trajectory of reform itself. Participants may find a rotating coordinator procedurally fair yet object to the system's loss of established reciprocal ties. Others may view the same reform as a release from an extractive dependence. These judgments may change cooperation policies even in an accurately observed network. Recording the reasons for disagreement, alongside the material effects of each reform, can help distinguish coercive stability from generative continuity. It cannot yield a single universally agreed metric of beauty, equality, or deserved return.

9.6 Spatiotemporal Durability and the Reproduction of Power

A before-and-after reduction in a specified unilateral-denial exposure set constitutes evidence only for the *selected* resource, authority, population and time horizon. Comparable assessment requires the same protected production requirements and explicit inclusion of any new gatekeepers created by the reform. For instance, removing an exclusive electricity supplier from the denial set while granting an unreviewable protocol administrator control over all transfers may relocate rather than diminish domination. Hence a successful reduction in one typed exposure must be accompanied by a search for new exposures at adjacent material, informational and constitutional interfaces.

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Power may be dissolved at one interface during one interval and reconstructed at another interface in a later period. A renewable-energy diversification project can reduce reliance on a supplier, but the future replacement of battery components may require rare materials supplied through a new bottleneck. A rotational governance structure can limit tenure at the scheduling interface, but a long-serving protocol designer may retain cumulative knowledge, control of update procedures, and the ability to influence eligibility criteria. The analysis of power must therefore include histories of intervention, latency of remedies, irreversible losses, the regeneration of productive conditions, and dependencies that extend beyond the named local circuit.

A reform's institutional durability can be tested through declared counterfactual disturbances: the failure of one supplier; the temporary removal of a certifier; a contested emergency order; a disagreement among reviewers; an extended energy shortage; and an attempt by a participant to obtain exceptional extraction rights. For each disturbance, inquiry should examine authorized alternatives before the relevant deadline, whether dissent is possible without disproportionate retaliation, and whether the system maintains essentials while allowing erroneous rules to be corrected. Repeated use of the same nominally distributed infrastructure should not be counted as independent redundancy.

It is possible that advanced AI cognition and shared production data will make the proposed institutions substantially more feasible than analogous arrangements under severe human cognitive limits. Forecasting tools may identify hidden common-mode dependencies, synthesize temporally viable alternatives, and compare the consequences of multiple governance choices. This epistemic optimism does not authorize a unique planning intelligence to become the unreviewable source of facts and norms. A technically capable global observer would itself occupy an important information interface. Its auditability, independence from allocation interests, and capacity to be challenged are therefore internal to the design.

The analytical test is one of *qualified diminution of domination*: are specified unilateral and poorly contestable powers less durable across an explicit time horizon, and has the reform avoided creating a comparably consequential unreviewable interface elsewhere? This question remains normatively mediated and cannot be settled solely by an exposure count. A decrease in the set represented by Equation 20 is one possible diagnostic where its assumptions hold. The same evaluation must also inspect productive continuity, distribution of burdens, ecological maintenance, and protected participation, including the legitimate refusal examined in Section 8.

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9.7 Monetary Dissolution, Legitimate Coordination, and Research Boundaries

The possible dissolution of specific dominating powers and the replacement of monetary coordination are related through the production relations they alter. A local circuit that replaces transferable money with resource-specific commitments may reduce exposure to price-based exclusion while introducing new dependencies on commitment registries, capacity allocators, and eligibility standards. A reform that makes those powers contestable and offers legitimate alternative routes may improve the credibility of nonmonetary participation, supporting the repeated fulfillment of resource-specific obligations. Conversely, an unreviewable allocation protocol can reproduce extraction even when monetary balances and payment transfers have disappeared from the circuit.

The ordering of institutional changes need not be fixed. A network may first diversify supplies, then replace monetary settlement for a narrow class of deliveries. Another network may begin with mutual-credit clearing, discover an emerging certification monopoly, and subsequently alter governance. A third may retain monetary instruments at its external interfaces because they improve coordination under uncertain or disputed claims, even while its internal productive relationships become more accountable. These are candidate developmental sequences, not stages of a law of economic history. Power changes across one interval do not imply proportional changes in money use, and the disappearance of a particular token does not establish a reduction of arbitrary interference.

A further possibility is that some forms of authority remain necessary precisely because a viable nonmonetary circuit depends on reliable emergency response, protection of third parties, enforcement of

valid commitments, and accessible remedies. The aim of non-extractive circulation is compatible with qualified, contestable authority, provided the sources and constraints of that authority can be defended. Eglash and collaborators' account of generative justice emphasizes the agency of value producers and the return of benefits toward the capacities of generating communities [6]. The present AI-network proposal adds a distinct problem: how material and procedural powers could be rearranged so that value return does not depend on a permanent unreviewable chokepoint. It does not attribute a distributed power-dissolution theory to that source.

The section has advanced a bounded institutional concept, a diagnostic set, a comparative reduction condition, and a case showing both resource-level improvement and protocol-level relocation. It leaves open the causal stability of these reforms, the normative assessment of conflicting claims, the long-term costs of redundancy and multi-level review, and the legal allocation of responsibility among AI operators and their principals. The next section considers how such localized transformations interact with monetary functions at network boundaries, including the re-emergence of common exchange media under uncertainty, disruption, and cross-circuit scarcity. The grammar of evolving circuits and power-bearing interfaces remains the independent object of Paper III.

10 Local Monetary Substitution and Systemic Re-Monetization

A productive network may progressively coordinate some resource transfers through direct entitlements, reciprocal commitments and shared scheduling while continuing to acquire essential inputs through a circulating payment medium elsewhere. Changes of this kind are central to the possibility of spatiotemporally distributed monetary dissolution. They also expose a difficulty for interpreting that possibility: reduced monetary use inside an observed circuit may coincide with monetary dependence at its boundary, the creation of transferable claims within the circuit, or the renewed adoption of money after a disruption. This section examines how localized substitution interacts with interfaces between heterogeneous AI-operated production networks. Its objective is to specify the conditions under which a local reduction is a meaningful institutional change, and to explain why cross-network exchange may reproduce or transform monetary functions. The argument proceeds from a boundary-sensitive accounting distinction through an overlapping-network case, the emergence of transferable claims, dynamic reversibility, and normative requirements for sustainable value return. The formal identity and institutional cases are conceptual diagnostics, not empirical demonstrations of a future economy or an equilibrium theorem.

10.1 Functional Substitution Within Bounded Production Domains

Suppose a group of autonomous or institutionally delegated AI operators manages agriculture, food processing, storage, and a share of its electricity supply. A cooperative authority recognizes their continuing claims to particular inputs, and a shared information system records production capacity, scheduled deliveries, maintenance needs, and prior fulfillment. A processor can then receive grain by an authorized delivery instruction and secure electricity through a capacity reservation. These activities may require neither a transferred monetary asset nor a generally circulating exchange token. Their organization nevertheless includes allocation, accounting, authorization, and enforcement. Under conditions of resource scarcity, each operation still confronts alternative possible uses of productive capacities and potentially incompatible claims.

The distinction developed in Section 2 is consequential here. The replacement of payment transfer in a specified transaction leaves open whether a common unit of account, transferable credit, or future purchasing power survives in another part of the arrangement. The absence of a monetary settlement asset within a registry does not establish an absence of obligations: the registry might record delivery entitlements that expire after performance, contingent rights to scarce capacity, or assignments that become negotiable among unrelated operators. The economic significance of the arrangement depends on how these different instruments are accepted, exercised, and discharged. A claim to a fixed quantity of

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electricity on a specified day has different mobility from an instrument accepted by many suppliers for heterogeneous resources, even when both are represented by comparable digital entries.

A local substitution is operationally meaningful when it preserves a specified bundle and timing of material production under stated resource constraints, established rights, and an admissible method of resolving conflicting requests. It is historically meaningful only when the arrangement can renew its productive conditions over a relevant period, including repair, replacement, input replenishment, and the allocation of environmental burdens. It may be normatively significant when participants can challenge improper allocation and when the return of productive benefits does not depend on extraction from an unrepresented party. These tests are analytically separate. A functioning nonmonetary schedule can be unjust; a justified refusal can temporarily interrupt an otherwise effective schedule. The broader framework of generative value return developed in Section 3 supplies reasons to evaluate those circumstances without assuming that monetary absence settles their legitimacy.

10.2 Boundary-Sensitive Observation of Monetary Reliance

Institutional accounts of monetary dissolution can become misleading when they select a circuit boundary so narrowly that all residual payment is registered elsewhere. A food cooperative may report zero internal purchases in currency while obtaining replacement batteries, specialized minerals, or external transport by ordinary monetary payment. The apparent achievement would then depend on an upstream transfer whose cost and conditions lie outside the observation window. The underlying material production still relies on that interface, even if its members experience no direct monetary transaction. Analogous difficulties occur across time when current deliveries draw on infrastructure acquired through earlier monetary expenditure or when future repairs require external monetary resources.

To expose one limited version of this problem, partition the eligible coordination tasks for a specified monetary function f into internal tasks K_f^{in} and boundary tasks K_f^{∂}. These sets are disjoint, and together constitute the task requirements selected for observation in the expanded domain. Preserve the function-specific monetary-use classification and comparable baseline task weights adopted in Equation 1. The two groups must be partitioned by a disclosed rule, so that an interface task is not counted again as an internal transaction and an internally allocated task does not disappear merely because no payment was recorded. Let W_f^{in} and W_f^{∂} be the sums of those positive weights in the respective groups, and let D_f^{in} and D_f^{∂} be the associated within-group shares. Provided both groups contain eligible tasks, Equation 21 gives the use share for their union.

$$D_f^{\mathrm{expanded}} = \frac{W_f^{\mathrm{in}} D_f^{\mathrm{in}} + W_f^{\partial} D_f^{\partial}}{W_f^{\mathrm{in}} + W_f^{\partial}}. \tag{21}$$

Equation 21 is an accounting identity, conditional on a mutually exclusive task partition and consistent weighting. For example, internal monetary payment may be absent while the external procurement share remains high. The expanded observed share would then remain positive whenever boundary payments have positive weight. The identity neither measures functional necessity nor identifies a justified weighting system. It does not follow monetary obligations through arbitrarily distant suppliers, determine a natural global network boundary, or measure ecological and governance costs. A serious assessment must therefore disclose which task types, times, interfaces, and externally maintained productive conditions were included. Where an interface involves heterogeneous obligations that cannot be compared under a defensible common weight, the corresponding functional shares should be reported separately.

This boundary sensitivity connects to the distinction between observed monetary use and feasible monetary substitution in Equation 2. A local reduction in observed use is compatible with an unchanged set of feasible economy-wide arrangements, or with a feasible nonmonetary alternative that has not yet been adopted. Conversely, an advanced AI coordination system might make a previously infeasible direct allocation possible, thereby changing the feasible set without immediately displacing entrenched settlement practices. The relevant evidence is consequently longitudinal and counterfactual: the pro-

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Table 9: Constructed two-period comparison of payment reliance with the same ten resource-coordination requirements under two stipulated arrangements. Each period has three internal and two boundary tasks; weights are equal within the payment-function comparison.

Task group, two periods	**Eligible tasks**	**Monetary baseline**	**Direct-allocation alternative**
Internal grain, bundled electricity and transport scheduling	6	6 monetary payments	0 monetary payments
Boundary equipment and battery procurement	4	4 monetary payments	4 monetary payments
Whole specified domain	10	Share 1	Share 0.4
Internal tasks only	6	Share 1	Share 0

ductive bundle, available resource alternatives, operative rights, eligible monetary functions, and claims crossing the selected boundary must be compared on explicitly stated terms.

A two-period numerical illustration makes the boundary effect observable without presuming that different resources have a common value measure. Assume that a food-production domain must satisfy three internal coordination requirements per period: deliver grain to processing, allocate a single jointly scheduled electricity bundle to farm, processing and transport, and provide scheduled transport. The same domain needs one externally supplied equipment component and one external battery replacement per period. All five requirements are specified in advance, use equal *task-count* weights, and are assumed feasible under both compared arrangements. Table 9 records whether the *payment* function is performed through an accepted monetary instrument under two stipulated procedures. The initial comparison concerns the payment function; Appendix A constructs an explicit physical schedule under disclosed resource and entitlement assumptions. Its legitimacy and empirical implementability still require independent assessment.

Under these assumptions, the alternative has no internal monetary payments, yet four of the ten required coordination tasks still use accepted payment instruments across the selected boundary. Equation 21 therefore yields an expanded payment-use share of 0.4 under equal task weights. This illustrative decline is attributable to the *specified* substitution of three internal payments in each period while output requirements are held fixed. Appendix A supplies a consistent material and claim ledger for these assumed requirements. The count proves neither that monetary accounting and credit functions have disappeared nor that the external component suppliers regenerate their production conditions justly. If an internal entitlement begins circulating as a generalized payment claim, the classification must be revised; if battery procurement is omitted by narrowing the boundary, the reported payment share no longer measures the same productive arrangement. The simple computation shows the comparison discipline required before a claim of local dissolution can be generalized.

The table also fixes a measurement convention rather than a natural unit of economic activity. In particular, the shared electricity reservation counts as a single eligible coordination requirement even though it supplies three different productive roles. Arbitrarily dividing its record into several smaller payment events would change an unweighted task-count statistic while leaving material output, ownership and payment authority unchanged. The sensitivity identified in Subsection 2.4 applies here. A later refurbishment regime can replace an imported component with internal reconditioning while still fulfilling the *same component-renewal requirement*; the changed supplier is a substantive institutional result, whereas changing the counted service denominator would prevent direct comparison. The original grouping as “boundary procurement” describes the first two-period configuration and should be updated when the supplier becomes internal. For these reasons, the fixed service requirement is the comparison unit, and actual internal or external procurement events are reported separately. This construction permits a bounded statement about payment-use substitution; it does not provide a partition-invariant universal measure of the monetary character of a production network.

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10.3 Shared Productive Capacity and Interperiod Regeneration in the Worked Example

The ten-task comparison in Table 9 assumes that the two institutional arrangements can meet the same resource requirements. That assumption must be checked independently of the payment ledger. Appendix A supplies a constructed physical and claims account, then considers overlapping resource circuits and a longer replacement horizon. The appendix is an accounting witness for the stated conditions, with separate inventory units and authorization assumptions. Its purpose is to identify possible feasible allocations and failures rather than to predict an efficient AI economy.

In the two-period food example, an agricultural operator delivers eight grain units per period; processing yields seven food units and one residual unit returned to the agricultural substrate. Electricity dispatch has six units of usable capacity, allocated as two for agriculture, three for processing and one for logistics. A separate maintenance role installs one externally supplied machine component and one battery module per period. The example keeps the specified soil, machinery and battery condition indices at operational thresholds, while the internal grain, jointly scheduled electricity and delivery entitlements are discharged by performance. The direct-allocation arrangement consequently uses monetary payment for four of ten fixed service requirements, compared with ten of ten under the stipulated payment baseline. These task shares are descriptive and depend on the disclosed denominator. The construction leaves external input reliance and upstream regenerative obligations unresolved; the complete schedule appears in Table 12 and Subsection A.1.

The extension in Subsection A.2 introduces a second circuit for refurbishment. A food recipe requiring six electricity units and refurbishment requiring two cannot both operate against a common capacity of six. Under the explicitly stipulated processing-efficiency improvement, the food recipe instead uses four and refurbishment uses two, allowing joint execution within capacity. The internal component-renewal service can then be fulfilled through refurbishment while external battery procurement remains monetary. The improvement is conditional on previously acquired technology, material recoverability, maintenance slots, institutional authorization and correct timing. Separate feasibility of each circuit does not imply feasibility of their simultaneous use.

The four-period construction in Subsection A.3 shows why the two-period result cannot be read as perpetual closure. The stipulated component permits only two refurbishments before external replacement, repair tools require periodic renewal, and the efficiency improvement depends on a prior acquisition. Table 14 records five monetary payments among twenty fixed service requirements, alongside an additional upstream tool-renewal purchase and a pre-observation retrofit acquisition. These quantities must be reported under distinct accounting boundaries: the five-of-twenty ratio is not the system's total monetary cost or the share of economic value mediated by money. Moreover, if electricity supply falls from six to five, the four-unit food recipe and two-unit refurbishment requirement cannot both proceed on schedule. Valid priority, deferral and recourse rules must then be determined institutionally. These limitations connect the material ledger to the trust and rights analyses in Sections 6 and 8.

The examples jointly establish a limited conditional possibility: an AI-operated domain may substitute directly authorized resource allocation for selected monetary payments while maintaining its specified physical throughput over a bounded horizon. They also demonstrate why global money use, systemic generativity, and fairness cannot be read from that payment count. The later cross-domain analysis concerns precisely the interfaces at which apparently closed local coordination retains or re-creates external claims and monetary instruments.

10.4 Overlapping Networks and the Coordination of External Inputs

Consider two recurrent production domains, designated $\mathcal{C}_F$ and $\mathcal{C}_M$. The first includes an agricultural AI, a food-processing AI, and a logistics AI operating under a shared food-allocation protocol. The second includes an energy AI, an equipment-manufacturing AI, and a maintenance AI coordinating their own deliveries. The domains overlap materially: agricultural irrigation, refrigeration and transport depend on energy, while the energy system relies on maintenance components and periodic replacement equipment. They may also be institutionally heterogeneous. The food domain could authorize resource-specific

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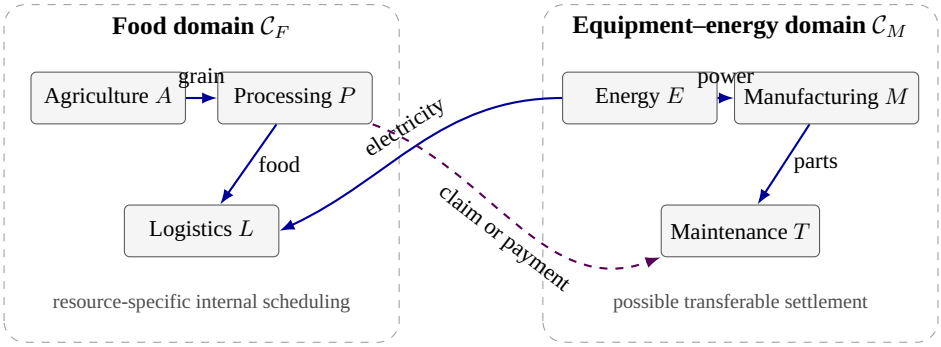

Figure 3: Illustrative interface between two AI-operated production domains. Solid arrows denote selected material services or resources; the dashed arrow denotes a hypothetical cross-domain claim or payment relation. The domains and arrows are analytically constructed, and their directions do not imply any necessary reciprocity or legal entitlement.

entitlements; the equipment domain could require settlement through a portable credit instrument; a third network might recognize particular energy-capacity certificates. Productive labour in all these domains is assumed to be performed predominantly by highly capable AI, but material resources and access powers remain constrained.

The boundary mechanism is illustrated schematically in Figure 3. The figure uses two institutional domains rather than two physically separate territories. Its dashed perimeter distinguishes authority and accounting arrangements, while the cross-domain links convey physical inputs, claim assignment and payment or settlement. A resource flow can cross the perimeter without a monetary transfer; likewise, a transferable claim can cross a boundary without corresponding immediate physical delivery. Both outcomes depend on their respective authorized rules.

Suppose the energy operator agrees to provide a defined electricity allocation to the food domain in return for reserved transport and processed food, with no circulating payment asset. This may be a feasible cross-domain nonmonetary arrangement when the expected quantities, delivery dates, reserve margins and rights are clear. But a sudden failure of the energy installation may necessitate manufacturing capacity unavailable within either previously agreed exchange schedule. The manufacturer might recognize only a broadly accepted settlement claim, especially when it must procure critical minerals or services from other operators. The food domain can then choose among temporary use of monetary payment at the interface, resource-specific emergency commitments, authorized rationing, new co-production arrangements, or postponement. The choices depend on the urgency and substitutability of needs as well as normative priority rules.

Even accurate, globally shared production data do not dictate which interface arrangement is rightful. Such data may reveal a feasible set of electricity deliveries and alternative schedules; they may also expose hidden dependence on mining, water extraction or prior investment. Yet the authority to appropriate reserve capacity, assign future repair burdens and prioritize competing needs remains an institutional question. Highly capable AI can enlarge the space of informed, contingent arrangements while participants continue to disagree over the legitimate allocation of scarce opportunities. A reduction of monetary reliance at the boundary is thus technically possible and normatively nontrivial.

10.5 Claims, Acceptance Conventions, and Local Re-Monetization

An attempt to replace money with specific promises can itself create a new object that performs monetary functions. Suppose E initially promises ten units of scheduled electricity to A. The resulting record has an identifiable issuer, a particular deliverable, and an expiration date. If A transfers the claim to P for milling services, and P accepts it because its own energy demand makes direct redemption useful, the claim remains closely attached to its productive content. Now suppose L accepts it despite having no immediate electricity requirement, expecting another supplier to accept it later for transport components.

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With repeated acceptance beyond direct use, the instrument begins to act as a medium of exchange. Standardized denominations and account conversion could extend its reach. The precise point at which it is classified as money is a matter of functional convention and explanatory purpose, rather than a material change in the record itself.

The possibility of endogenous acceptance has a theoretical precedent in the monetary-search literature. In their specified model, Kiyotaki and Wright show how commodities can emerge as exchange media under expectations and matching frictions [19]. That result neither assumes highly capable AI nor establishes a general law of future digital credit. Here the thought experiment is broader: operators may hold extensive data and engage in repeated multilateral production. The conditions motivating generalized exchange media could therefore shift. An energy claim might remain tightly resource-specific because exact delivery schedules are observable and easily coordinated; in another configuration it might gain wide acceptability because participants value portability under uncertain future needs. The two trajectories can coexist in overlapping domains.

Commitment pooling provides a limited present-day comparison. Grassroots Economics describes vouchers as traceable promises of future goods or services that may be transferred, redeemed, and, in some arrangements, subsequently reused [13, 12]. Those practices concern human communities and must not be portrayed as a demonstrated economy-wide disappearance of monetary functions. For the present inquiry, the instructive distinction is between the underlying resource obligation, its circulating representation, and the social recognition enabling third parties to accept it. The classification of a particular voucher as money-like is our functional analytical judgment and need not coincide with the issuing community's terminology.

Three different institutional consequences follow. First, a debt can be extinguished through valid performance or multilateral set-off while the wider economy retains a circulating payment medium. Second, a transferable claim can return to its issuer after redemption and be extinguished, left in the issuer's inventory, or newly issued under a subsequent commitment; these are distinct institutional events. Third, a locally nonmonetary arrangement can give rise to a new generalized exchange convention even though no established currency was used in the original transfer. Currency-specific substitution and function-specific monetary dissolution therefore need to be evaluated separately. The emergence of a common accounting scale may also occur without a circulating settlement asset. If a particular claim later becomes broadly accepted, its newly acquired function may represent re-monetization in that domain, even while another established currency remains absent.

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10.6 Reversibility Under Disruption and Institutional Change

The adjective *distributed* concerns more than spatial variation. A resource-coordination rule can remain stable across many seasons, then be reconsidered following a new bottleneck, production technology, emergency, or dispute over recognized rights. A formerly transferable token may lose acceptance following issuer default; a resource-specific entitlement may become a generalized claim as the range of counterparties expands. Payment conventions can consequently emerge, disappear and return at different interfaces over different periods. Their histories need not converge toward a single institutional endpoint.

The circuit-fragility analysis of Section 8 identifies one route by which monetary demand may return: a breakdown of trusted reciprocal performance can increase the appeal of an asset with wider acceptance, credible discharge, or external liquidity. That response is contingent. Where disruption is caused by actual scarcity of physical inputs, the introduction of a payment asset cannot restore absent electricity or food. Where the bottleneck lies in disputed authority, resort to a centralized currency may relocate power without resolving legitimacy. Where shared records and authorized alternatives are adequate, the disrupted circuit may instead restore coordination without a generalized medium. Money is therefore one potential response to missing coordination guarantees, not a universal remedy for circuit instability.

Shared production records also affect these comparisons, within limits. Kocherlakota's "money is memory" result concerns economic environments in which fuller memory supports allocations feasible with money [20]. A related model examines record-keeping with delayed updates [21]. These theorems

and models do not establish that perfect global knowledge is available, that advanced AI can deduce the rightful allocation, or that money becomes universally unnecessary. Their value for the present thought experiment lies in identifying the informational and commitment conditions that must be specified before generalized payment can be replaced. An AI-operated system may exploit richer records, stronger forecasting and better verification than many human-mediated historical arrangements, but it also confronts changing institutions, finite computation, model error, strategic withholding of truthful records, and contested priorities.

Historical persistence also warrants attention. Widely used monetary instruments can be embedded in technical interfaces, credit contracts, reserve policies and expectations of future acceptance. Coordination around an incumbent standard may survive the introduction of a feasible alternative, just as path-dependent technological adoption can persist under certain increasing-returns conditions [2]. The analogy is qualified: no claim is made that Arthur's model specifies the transition of AI-generated monetary conventions. It nevertheless cautions against inferring actual institutional replacement directly from theoretical feasibility. Conversely, a locally adopted nonmonetary arrangement may become durable through investment in shared records, replenishment reserves and dispute-resolution procedures. Both outcomes depend on their history and on the adaptation of neighboring networks.

10.7 Cross-Domain Governance and Generative Viability

A viable multi-domain production arrangement must manage risks that extend beyond bilateral exchange. A food network may require continuous energy, while an equipment network may require ecological remediation and public access to transport. Distinct coordination protocols may have different rules for priority in scarcity, accepted credit, or the eligibility of external participants. Interoperability cannot be understood solely as the technical ability to transmit a transaction record. It also requires agreement about the authority of an issuer, the performance that counts as discharge, appropriate recourse when obligations fail, and the institutional process by which common or conflicting claims are reviewed.

Polycentric governance supplies a cautious institutional comparison. Ostrom's account of complex resource governance examines arrangements in which multiple centers of decision coexist with coordination and monitoring [24, 25]. The historical studies do not supply an operational blueprint for AI production. Their relevance here is to warn against identifying network-wide cooperation with a single sovereign optimizer or a single currency issuer. A future AI network might employ local common-resource authorities, interoperable information ledgers, emergency procurement protocols and jointly revisable eligibility rules. Every interface would still need a method for representing affected parties, including those who bear external resource or ecological costs.

Table 10 compares several institutional patterns. The patterns are analytically possible under the hypothetical conditions; they are neither an exhaustive classification nor empirically estimated transition probabilities. In each case, lower internal monetary use has a different relation to external dependence and to the network's generative capacities.

The idea of generative value return adds further tests of adequacy. Eglash and collaborators argue for attention to the capacity of value-generating communities to sustain and control their contributions and to non-extractive circulation across productive, social and ecological domains [6]. The present analysis develops a distinct AI–AI extension: benefits of a circuit's output should be examined together with the replenishment of energy systems, maintenance resources, ecological conditions, and legitimate participation capacities that made the output possible. It is possible for obligations to circulate without a commonly traded medium while costs are concentrated on an unrepresented maintenance operator. It is also possible for a circulating monetary claim to help secure fair compensation and long-term regeneration in a particular domain. Neither arrangement receives a positive generative assessment solely because of its payment technology.

The power analysis in Section 9 makes another condition visible. A locally eliminated currency can leave intact a resource gatekeeper's power to refuse indispensable inputs. An ostensibly interoperable global ledger can create new discretionary power for its certification authority. A portable token can make

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Table 10: Local monetary substitution, boundary coordination and possible re-monetization across AI production domains.

Institutional pattern	Internal coordination	Boundary dependence	Principal viability or governance question
Local entitlement scheduling	Typed delivery rights and shared capacity plans	Purchased external materials may remain monetary	Are external inputs and maintenance burdens included in the assessment?
Multilateral commitment network	Reciprocal obligations and admissible set-off	Some net obligations may require external discharge	Can parties contest, verify, and lawfully settle every relevant claim?
Emergent transferable certificate	Initially resource-specific performance records	Third-party acceptance creates new exchange capacity	Does portability increase flexibility while concentrating issuer power?
Temporary external payment	Nonmonetary internal operations continue	Settlement asset used at a disrupted interface	Does the payment resolve coordination or only reallocate a scarce resource?
Cross-domain shared allocation	Compatible entitlement protocols and joint reserves	Partial substitution of general purchasing power	Are allocation authority, repair, and ecological costs reviewable?

operators less dependent on a local supplier while increasing dependence on an issuer's redemption and governance conditions. The degree of monetary substitution and the degree of exposure to domination can therefore move in either direction. A defensible institutional comparison must state both dimensions and examine the available routes for exit, appeal, alternative sourcing and rule revision.

10.8 Spatiotemporal Interpretation and Scope of the Dissolution Hypothesis

Within the present thought experiment, the most defensible version of the monetary-dissolution hypothesis concerns multiple, bounded processes. A local circuit may reduce routine payment through shared schedules; its external interfaces may employ claims with varying transferability; and crises may produce temporary recourse to money or a new convention of exchange. Over time, the set of domains that can satisfy authorized resource requirements with minimal monetary reliance may expand, contract, or shift. Such changes may be observed through distinct functional-use measures, explicit records of boundary transfers, and independent assessments of resource regeneration, valid authority and durable cooperation. The resulting description is a historical mosaic rather than a once-for-all classification of an entire future society.

The thought experiment offers no general proof that larger AI networks necessarily require currency or that increasingly capable AI necessarily dissolves it. Complex but comprehensible resource relations can be coordinated through physical schedules, registries and commitments under some assumptions. Highly heterogeneous resources, disagreement about authority, unreliable information and unpredictable contingencies can favor portable claims in others. The basic presence of a repeated value circuit is insufficient to decide between these mechanisms. Its normative worth also requires scrutiny of whose production conditions are replenished, which ecological and social costs are assigned outside the loop, and who can legitimately challenge the rules by which the circuit is closed.

The framework consequently identifies a limited but constructive research agenda. Empirical or computational extensions would need temporal production data, cross-domain access-rights descriptions, event-level payment records, counterfactual coordination policies, and measures of material interruption. Formal-grammar analysis of circuit construction, recursive subcircuits, and compositional expressiveness belongs to the independent Paper III. Within Paper II, the central task is to state the conditional

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relations among monetary functions, recurrent production, incomplete epistemic access, trust, power, and justified value return. The concluding section will bring those relations together while maintaining the distinction between an illuminating institutional possibility and a demonstrated future economic outcome.

11 Conditions and Limits of Distributed Monetary Dissolution

The preceding analysis has examined the possible attenuation of monetary coordination in an economy whose productive operations are performed predominantly by highly capable artificial-intelligence systems. Its principal object has been the transformation of production relations across local and overlapping circuits rather than an anticipated terminal state of the economy. The concluding section consolidates the argument at three levels: the criteria by which a particular monetary function may be said to diminish, the productive and institutional conditions under which such a change can remain viable, and the epistemic and normative questions that remain unresolved. This synthesis is conditional and comparative. The paper establishes conceptual distinctions and develops candidate mechanisms within a thought experiment; it supplies neither a theorem of historical inevitability nor empirical evidence that advanced AI production will eliminate money.

11.1 Monetary Functions and the Object of Institutional Change

The initial premise of the thought experiment is demanding in one respect and deliberately restrained in another. Artificial-intelligence operators are assumed capable of performing almost any type of productive labour and of coordinating extensive portions of production among themselves. Their productive opportunities nonetheless remain dependent on energy, materials, location, time, equipment, infrastructural maintenance, and effective authority to use or transfer those resources. Universal competence in performing a task leaves the supply of the task's material conditions to be organized. That asymmetry permits an economy of almost exclusively artificial labour to retain scarcity, heterogeneous claims, and interdependent production relations. The appearance of a monetary medium within such an economy is possible, as is the coordination of some activities without one.

Section 2 distinguished the functions often grouped under the name *money*. A common unit of account, a widely accepted medium of exchange, an instrument of payment, a means of final settlement, an intertemporal claim to purchasing power, and arrangements for credit can be combined in a single institution or distributed among several. An organized production network can preserve accounting without circulating a general payment object; it can execute resource-specific rights without conferring transferable purchasing power; it can also create a locally accepted claim through repeated adaptive practice without a prior comprehensive monetary charter. These possibilities counsel against treating the presence or absence of a recognizable currency as a complete description of monetary coordination.

The descriptive test should also compare the same coordination requirements across alternative arrangements. A decline in recorded payment events may follow from changing transaction boundaries, a contraction of output, or a new money-like convention that the observer has failed to classify. Consequently, the function-specific indicator in Equation 1 and its counterfactual counterpart in Equation 2 can inform the discussion only when the event baseline, function classification, and admissible comparison set are explicit.

The corresponding uses of *dissolution* likewise require separate tests. A debt may be validly discharged, a particular service claim may expire after redemption, a payment function may be replaced by a direct resource schedule, reliance on generalized purchasing power may diminish over several periods, or a previously operative monetary institution may cease to organize a specified domain. The first two processes concern particular instruments and obligations. The latter three involve the organization of economic action and may persist after the relevant obligations have been settled. The paper's hypothesis of distributed monetary dissolution applies primarily to these institution-level changes, while treating debt clearance and claim redemption as possible components rather than decisive evidence.

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Money can therefore be understood, for present purposes, as a variable configuration of functions embedded in historically constituted exchange and production relations. Monetary theory supplies distinct reasons why generalized media may be useful in some environments and less necessary in others: Kiyotaki and Wright examine the endogenous emergence of exchange media under specific trading conditions, while Kocherlakota examines the informational role of memory under specified allocation assumptions [19, 20]. Neither result licenses a general prediction about a future AI economy. Their limited relevance here is to identify the exchange, acceptance, record-keeping, and enforcement assumptions that require explicit specification in any account of monetary persistence or substitution.

11.2 Local Circuits, Temporal Boundaries, and Systemic Dependence

The spatiotemporal claim of the paper is that changes in monetary reliance may occur unevenly among production domains, across interfaces between domains, and over different periods of productive reproduction. A food-production group might coordinate grain, electricity, processing, and transport through authorized access schedules and shared capacity records, while an equipment-production group uses transferable settlement claims to secure specialized inputs. Their common future is not decided by classifying either group as monetary or nonmonetary once and for all. Instead, the relevant research task is to identify which coordination functions each arrangement actually employs, at which interfaces, and with what continuing dependence on neighboring production networks.

The boundary problem introduced in Section 10 has substantive consequences. An internally self-clearing circuit may purchase replacement machinery or critical materials from outside its accounting boundary. If the outside payments are omitted, an apparent disappearance of money can be an artifact of classification. Equation 21 expresses an illustrative aggregation across internal and interface transactions; its function is descriptive rather than normative. A change to the geographic, institutional, or temporal boundary changes the observed profile, so the claimed achievement must report the chosen boundary and dependencies that extend beyond it. The same principle applies to upstream energy use, data and computation infrastructure, ecological inputs, and obligations carried into subsequent periods.

The two-period material account in Appendix A, Subsection A.1 improves on a bare payment-count comparison by fixing a specific food-delivery bundle, a joint electricity constraint, three separately renewable productive-condition indices and the actual disposition of resource-specific claims. Table 12 shows that local payment substitution and the modeled replenishment schedule can coexist during the stipulated horizon. The same calculation also retains monetary purchases of external components and shows how a missed battery replacement defeats an assumed third-period capacity threshold. This is a constructed finite-horizon feasibility witness, not a verified economy-wide production plan or an assessment of distributive justice.

An overlapping-circuit extension in Appendix A, Subsection A.2 tests the joint-capacity issue more directly. Adding a separate component-refurbishment loop to the original food recipe requires eight electricity units from a shared six-unit source and is therefore infeasible as a simple superposition. Under a stipulated, already available energy-efficient processing recipe, both circuits can instead operate with the same six-unit supply while a reused component restores machinery condition and an external battery purchase continues. Table 13 records the two-period comparison across unchanged functional service requirements. The result depends on a restrictive refurbishment assumption, timing, and initial technology; it gives neither perpetual circularity nor a general comparative measure of monetary reliance. It illustrates why checking one circuit at a time is inadequate for evaluating a portfolio of shared production activities.

A further durability extension in Appendix A, Subsection A.3 lengthens the overlap example to four operating periods and explicitly records limited component reuse, repair-tool renewal, a prior processing retrofit, and priority rules under shared-energy shortage. Table 14 separates five monetary payment uses within twenty fixed service requirements from an additional tool-renewal purchase and a preliminary retrofit acquisition. The purpose of this extension is diagnostic: a two-period self-renewal witness can conceal later replacement needs and inherited technical costs. A five-unit electricity shock in the second

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period also makes the food and refurbishment tasks jointly infeasible under their stipulated recipes, requiring a justified priority decision and a possible external fallback. The function-level payment ratios in these comparisons further depend on a predeclared unit of service: merely splitting a shared electricity instruction into several entries cannot establish a real change in monetary reliance. The resulting network-level inference remains conditional on rights, upstream material accounts and review procedures. Neither the four-period functional-use fraction nor the repaired production cycle establishes a socially complete or indefinitely sustainable nonmonetary economy.

The circuit itself also has to be identified carefully. Section 4 distinguished a simple directed cycle from a closed walk that repeats vertices or edges, and both from a materially executable sequence of production events. A finite static network can contain immensely many simple cycles and, where returnable cycles can be repeated, infinitely many distinct closed walks. The count of syntactically distinct walks is not a count of separately produced value or independent rights. The economic question concerns typed resource transfers, feasible delivery dates, shared capacities, legally or institutionally admissible commitments, and the effects of using common inputs in several purported circuits. The temporal feasibility and shared-capacity constraints formulated in that section make these differences explicit within the paper's limited structural model.

Figure 3 illustrates why the relevant domain is usually a network of interacting circuits rather than a neatly sealed ring. Resource-specific commitments can support coordination inside one domain while claims with broader transferability emerge at its boundary. When a new supplier accepts an instrument because other suppliers are expected to accept it, a convention with monetary functions may arise endogenously. Accordingly, local substitution, cross-domain monetary use, and later re-monetization can coexist. The historical significance of any observed decline in payment depends on its durability under recurrent production and on what forms of coordination arise elsewhere as a consequence.

11.3 Generative Value Return and Material Reproduction

The paper has also proposed that a successful coordination arrangement be assessed against the continued conditions of value generation. Eglash and collaborators' work on generative justice provides a normative point of comparison concerning the agency of value-generating communities and forms of circulation that sustain social, ecological, and productive capacities [6]. The present paper extends this concern to the thought experiment of AI-operated production and does not attribute that particular model or its proposed mechanisms to those authors. The extension asks whether an arrangement allows benefits, resources, replenishment, and relevant decision-making capacities to return to those contributors and enabling structures on which further production depends.

A production circuit may circulate grain, processed food, energy, and repair services without transferring a general payment asset. Its apparent success in the current period may nevertheless rely on uncompensated maintenance, depletion of a common ecological resource, inaccessible infrastructure, or exclusion of participants whose contributions occur outside the measured boundary. Section 3 separated material stock and productive-capacity renewal from the settlement of claims, while its interperiod accounting representation made external inputs and renewal costs explicit. Such accounting can identify an omitted burden or a threatened capability without independently deciding which contributor has a just claim to every increment of collective output.

The difficulty grows when the same infrastructure supports several overlapping circuits. A transport system, energy reserve, or software-maintenance process may enable multiple products simultaneously. Allocating its contribution uniquely to a particular closed walk requires conventions that reflect a defined analytical purpose; no enumeration of paths supplies a uniquely correct moral division of the resulting benefits. The value of a circuit can thus be discussed through several dimensions: continuity of essential production, the repair and replenishment of enabling conditions, recognition of legitimate contributions, participation in rule-making, and the distribution of avoidable costs and risks. These dimensions may conflict and need not be reducible to a single monetary or nonmonetary measure.

This separation is important when evaluating money's disappearance as a possible ideal. An effi-

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cient clearing mechanism can settle obligations while the productive system becomes less regenerative. Conversely, monetary payment may sometimes support just compensation, maintenance and ecological renewal within a given institutional setting. A reduction of generalized payment should consequently be evaluated alongside, and never substituted for, the continued generative adequacy of the production relation. The paper proposes that institutional comparison retain both forms of evidence, particularly where the conditions of production are shared across persons, AI operators, organizations, and ecological systems.

11.4 Epistemic Capacity and Adaptive Coordination

A constructive possibility remains open even after these constraints are acknowledged. Historically familiar limits on nonmonetary coordination include fragmented information, complex interdependence, rapidly changing capacities, and the difficulty of updating large systems without excessive delay or error. The counterfactual considered here assumes unusually capable AI operators with access to broadly shared production data. Their ability to infer network structure, identify resource bottlenecks, evaluate alternative feasible schedules, and revise plans in response to new conditions may substantially enlarge the domain within which resource-specific coordination can replace generalized payment. This is a hypothesis about future capabilities and institutional design, not a conclusion from present-day evidence of AI system performance.

Section 5 distinguished observing transfers, reconstructing hidden network relations, identifying causal and dynamic mechanisms, and assessing the legitimacy of the resulting allocation. Each task imposes different informational and institutional requirements. Enhanced observation can improve the reliability of shared capacity records; stronger system identification may support better forecasts of material bottlenecks; rolling and uncertainty-aware planning may make revised allocations operationally feasible. These improvements need not require a complete enumeration of all closed walks or a perfect forecast of every future disturbance. The relevant task may be to find a defensible, feasible policy for a bounded production obligation with adequate safeguards and a capacity for timely correction.

The same optimism has boundaries. Joint access to production data does not establish that observations are complete, that the physical dynamics have been correctly identified, or that competing AI operators have identical preferences and legitimate interests. A policy that appears robust under one model can be vulnerable to rare changes in topology, previously unrecorded ecological costs, or disputed permissions to use an asset. Globally shared information can also coexist with concentrated control over data certification, prediction infrastructure, permitted model updates, or authorized implementation. Thus epistemic expansion may improve nonmonetary feasibility while generating additional institutional questions about the authority exercised through information systems.

The qualified result is nevertheless significant for the philosophical scope of the paper. Historical difficulty in operating a nonmonetary production relation need not establish its impossibility under different capacities for observing and coordinating relations. The imagined AI economy invites a comparison of institutional feasible sets across informational regimes, production technologies, resource conditions, and arrangements of legitimate authority. Technical improvement may alter which monetary functions are convenient or necessary for specified transactions. The choice of norms by which competing feasible allocations are judged remains a further question.

11.5 Normative Plurality, Trust, and the Fragility of Circulation

The normative dimensions of the thought experiment complicate the relation between feasibility and desirability. Participants may judge the return of value according to contribution, need, risk, historical commitments, ecological preservation, or the quality of their relations. The argument in Section 6 kept three objects distinct: an institution's justified treatment of participants, a participant's evaluative representation of that treatment, and the actual decision to continue, renegotiate, or withdraw from cooperation. Perfectly accurate information about resource transfers would leave room for reasonable disputes about

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the principles of allocation and about the legitimate authority to interpret them. The question of fairness can accordingly generate a second-order question about power over the rules by which fairness is assessed.

The terminology of *perceived* fairness requires special care in an AI economy. The paper assumes neither human-like conscious feelings nor an ultimate moral status for hypothetical AI operators. It models evaluative reports, internal policy states, decisions, and the claims of the legal or collective principals they may represent. An operator can respond to an encoded assessment of unfairness by demanding justification, restricting a transaction, seeking alternative suppliers, or requiring a more enforceable claim. Those responses can be economically consequential even where the assessment is mistaken, incomplete, or normatively contested. Conversely, a true injustice may be unrecognized or tolerated because an operator lacks a timely alternative.

Section 8 therefore distinguished legitimate refusal from opportunistic obstruction. A supply interruption can expose exploitation and create an opportunity for review, just as it can be used to threaten the extraction of excessive advantage at an indispensable resource interface. Reliable circulation is one desideratum of institutional design, yet throughput imposed by unreviewable coercive power would provide an inadequate measure of generative justice. A more defensible criterion examines whether a system can preserve indispensable production, permit reasoned contestation, remedy unjustified harm, and recover cooperation without forcing participants to surrender legitimate claims.

Trust, resource availability, and institutional authority also interact dynamically. A failed delivery may lead to lower confidence, tighter credit, reserve hoarding, or revised routing; each response can affect a neighboring circuit and feed back into the original relationship. Redundant input paths, buffer stocks, documented commitments, independent review, and revisable rules may reduce a network's exposure to a single interruption, subject to costs and limits of those safeguards. These are candidate mechanisms, rather than guarantees of stable future behavior. They provide a reason to study resilience as a historically adaptive capacity that includes legitimate refusal and repair, with no presumption that every disruption should be prevented by the exercise of superior force.

The recursive multiplicity of formally possible circuits adds a conditional qualification to the epistemic argument. A longer serial history may expose the material flow to more independently vulnerable commitments, so its effective influence can decline with length. Yet the number of candidate histories may grow sufficiently quickly to outweigh this attenuation. Section 8.5 therefore distinguishes the survival of individual circuits from the convergence of aggregated high-order effects, and sketches the conditions under which a finite effective-depth approximation is defensible. If those conditions can be verified, advanced AI may coordinate complex production without exhaustively enumerating its unbounded family of formal closed walks. Such an approximation says nothing by itself about the justice of curtailed pathways or the legitimacy of refusal. Moreover, independently usable parallel routes can improve the probability of satisfying a requirement even while each serial route remains vulnerable; the worked diagnostic in Equation 18 separates this redundancy effect from weighted-walk summation. Shared bottlenecks and correlated decisions limit any such redundancy benefit.

11.6 Distributed Power, Re-Monetization, and Reversibility

The governance analysis adds a further condition to the monetary-dissolution hypothesis. Where one operator controls the only available input, where another determines who may receive a resource, or where a protocol administrator alone certifies valid claims, nominally nonmonetary circulation can remain subject to extensive discretionary control. Section 7 distinguished instantaneous balance of countervailing capacities, spatiotemporal balance across changing positions and periods, and a proposed generative balance judged by the continued capacity for legitimate and regenerative production. Mutually opposed vetoes may produce strategic symmetry and material deadlock. Temporarily concentrated coordination powers may sometimes sustain urgent production, provided that their justification, scope, duration and review are defensible.

Section 9 made the stronger institutional proposal more precise. The object of distributed power

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Table 11: Distinct empirical and normative questions for evaluating conditional monetary dissolution in AI production circuits.

Assessment dimension	Candidate observation or comparison	Principal interpretive limit
Monetary function	Recorded use of payment, transfer, settlement and accepted claims	Limited use of a currency can conceal new money-like conventions
Material viability	Timely inputs, essential output, inventories and reserve sufficiency	A technically closed circuit can depend on unrecorded external resources
Regenerative return	Maintenance, ecological renewal, continued access and affected contributors	A contribution allocation requires contested normative judgments
Epistemic adequacy	Error-aware forecasts, observability, alternate-path recognition and correction	Greater predictive accuracy cannot determine legitimate priority
Legitimate coordination	Authorization, contestation, refusal, remedy and rule revision	Uninterrupted flow can coexist with domination or injustice
Boundary resilience	Interface payments, disruptions, credit portability and recovery paths	Local substitution need not reduce system-wide monetary reliance

dissolution is a specified, durable and insufficiently contestable position of unilateral domination. Its diminution can occur through genuine alternative supply, shared reserves, time-limited authorization, protected challenge procedures, and revisions of the interfaces through which resources and records are controlled. Such changes may reduce a material supplier's leverage yet relocate discretion to a data certifier or protocol owner. The proposed loss of domination must consequently be assessed across interfaces and over a meaningful time horizon. Legitimate productive capacity, emergency coordination and review authority remain necessary components of many candidate arrangements.

The relationship between monetary and power dissolution is therefore contingent. Replacing monetary exchange with a collective allocation ledger may reduce exposure to a payment issuer while increasing exposure to the ledger's administrator. A portable monetary instrument might, in a different setting, give a resource-dependent operator an effective exit option and reduce the ability of a local supplier to extract concessions. Monetary and nonmonetary arrangements have to be judged by what they enable and constrain within actual institutional relations, including their capacity to redistribute governing power to hidden levels. Disappearance of one medium provides neither a proof of diminished domination nor a reason to dismiss the possibility that genuine domination might sometimes be reduced by institutional redesign.

Re-monetization belongs within the same analysis. A formerly resource-specific entitlement may become transferable to unrelated third parties, acquire wider acceptance and begin to perform monetary functions. A disrupted nonmonetary circuit may also reintroduce payments, collateral or portable settlement claims as ways of coping with unreliable commitments. Conversely, new cooperative capacities and better informational coordination may later reduce the need for those instruments. Local monetary dissolution and renewed monetary emergence are historically reversible possibilities; neither process, by itself, determines the legitimacy or durability of the production relations that support it.

11.7 Comparative Evaluation and an Open Research Agenda

A more systematic assessment of the proposed transformation will require observable distinctions among competing institutional designs. The present paper offers candidate questions rather than an empirically calibrated index. Table 11 organizes the central dimensions in a form intended to guide subsequent comparison of otherwise similar AI production scenarios. The dimensions are complementary; a favorable result on one does not compensate automatically for a violation of justified resource rights or for uncompensated environmental depletion.

A first possible research design would compare, within the same constructed network and with the same resource endowments, several coordination regimes: generalized monetary payment, resource-

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specific entitlements, reciprocal commitments with admissible clearing, and a hybrid of monetary interface settlement with internally shared productive capacities. Differences in information access and predictive reliability could then be varied separately from differences in property authority, review procedures, and trust-updating rules. This comparison would help test whether advanced AI cognition contributes to the operational feasibility of a nonmonetary arrangement, while identifying the circumstances in which its apparent success relies on shifting costs or liabilities outside the observed circuit.

A second research design could focus on disruptions in networks with overlapping physical dependencies. Investigators could vary the number of independent energy paths, the renewal rate of shared equipment, the scope of transferable credits, the availability of procedural remedies, and the ability of a key supplier to deny access. Outcomes would include unmet essential demands, cross-domain resource bottlenecks, reliance on general settlement assets, and the durability of replenishment. A normative analysis of claims and rules would remain separate from these outcome measures. A favorable technical result would establish that some arrangement operates under its declared assumptions; it would not establish that affected parties have accepted its authority or that all distributions are justified.

Several issues would remain beyond such models. Actual AI legal and moral status, the rights of human and nonhuman beneficiaries, the distribution of environmental costs, and the legitimacy of institutions representing absent contributors require independent examination. Likewise, the proposed generative grammar of value circuits, including recursive subcircuits, grammar expressiveness and formally characterized admissible histories, is the object of the companion Paper III. Paper II has used graph and temporal-network representations to clarify feasibility and overlap, while leaving open the stronger formal question of which rule systems generate economically executable and normatively interpretable classes of circuits. That division prevents a useful descriptive formalism from being presented as a complete theory of production or justice.

11.8 Historical Possibility and the Limits of the Thought Experiment

The argument supports a limited but meaningful possibility. Under near-universal AI labour, finite and heterogeneous resources still require coordination. Some AI production domains may nevertheless become capable of maintaining recurrent resource exchanges through shared information, resource-specific commitments, valid multilateral settlement, adaptive planning, and revisable governance. If those arrangements reduce the role of general purchasing power across their actual material boundaries and over sufficient periods of regeneration, they would constitute instances of the paper's proposed distributed monetary dissolution. Their feasibility would depend on technological, informational, institutional, and normative conditions, and their continuation would remain exposed to changing resource requirements, conflicts, and new monetary conventions.

This possibility also qualifies historical pessimism about coordination. Human societies have faced substantial limits in observing and coordinating interdependent economic processes. Highly capable AI may expand the feasible range of planning and reciprocal exchange. It remains possible that certain monetary instruments will prove convenient even under excellent shared information, that some local circuits will require money-like objects only at their external interfaces, and that arrangements will combine multiple coordinating techniques indefinitely. The relevant achievement is therefore the expansion and just governance of feasible production relations, considered alongside the specific functions that cease to require a monetary medium.

The philosophical conclusion is one of conditional transformation. Money may be generated, used, locally displaced, and generated anew through evolving relations of production. The disappearance of a payment instrument, the lawful settlement of an obligation, the regeneration of productive conditions, and the reduction of domination describe different historical processes. Their possible coupling is a subject for inquiry rather than an accomplished identity. By preserving the distinction between functional coordination, institutional authority, and generative value return, the paper identifies circumstances under which monetary dissolution merits investigation without making its occurrence a necessary consequence of artificial intelligence or a sufficient measure of a just productive order.

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A Material, Claim, and Durability Ledgers for Overlapping AI Production Circuits

This appendix documents the bounded production schedules invoked in Section 10. Its objective is to make the relationship between material deliveries, available capacity, resource-specific claims, interperiod regeneration, and selected monetary payment practices reproducible under disclosed assumptions. The first schedule records two periods of grain, electricity, food delivery and external component procurement; the second tests two circuits competing for electricity and maintenance resources; the third extends the construction to four periods to expose refurbishment limits, repair-tool renewal and priority under a supply shock. These are hypothetical existence witnesses and counterexamples. Their quantities are stipulated for logical comparison and do not estimate actual AI-operated industries, a monetary equilibrium, or distributive justice. The main text states the mechanism-level conclusions without requiring the reader to reproduce each ledger.

A.1 Interperiod Material Balances and Claim Discharge in a Bounded Food Circuit

The payment-use comparison in Table 9 stipulates that production remains feasible under both institutional alternatives. A more demanding comparison must exhibit an actual schedule of typed material flows, show how critical productive capacities survive successive periods, and identify the obligations left outstanding. The following construction supplies such a schedule for the same ten eligible coordination tasks. It is a deliberately small *existence example under stipulated assumptions*, with quantities chosen for internal consistency rather than estimated from an agricultural or energy system. The model tests the logical compatibility of a local payment substitution with a recurring material process. It does not identify efficient production, characterize a general market equilibrium, or prove that the arrangement is just.

Operators, production boundary, and event timing. Five AI-operated roles comprise the internal circuit: agriculture A, food processing P, renewable electricity dispatch E, logistics L, and common-capacity maintenance T. An external supplier X provides two distinguishable replacement inputs, one machine component and one battery module per period. The internal coordination authority, whose legitimacy is stipulated only for this calculation, authorizes three composite requirements in each period: eight grain units from A to P; one scheduled electricity bundle from E allocated to the three operating roles; and delivery by L of the resulting food output. The electricity bundle is a *single* coordinated resource requirement with multiple named recipients, rather than three additional payment events. A processing by-product is returned to the agricultural substrate as part of the agreed physical transformation. Since this return has no separately negotiated transaction in the stipulated protocol, it is represented as a physical subflow rather than a fourth eligible payment task. An implementation that makes residue return a separately contracted obligation must disclose and revise the denominator used in Table 9.

Two equal-length periods, $t = 1, 2$, are observed. Within each period the renewable power operator first allocates a capacity-constrained electricity bundle. Agricultural production then delivers grain, processing produces food and residue, logistics delivers food to an authorized recipient outside the productive operator set, and residue is returned for soil maintenance. Components ordered from X are installed before the start of the following period. The constructed schedule assumes the necessary ordering and delivery windows can be honored. These temporal precedences are essential: a record of annual totals would not show whether grain arrived before processing or whether a replacement battery became available before the next period's dispatch.

Typed throughput and joint capacity. All grain, food and residue quantities are expressed in deliberately simplified common *material-equivalent* units solely to close this local transformation account. Electricity is measured in a distinct energy unit, and neither its quantity nor its importance is reduced to material mass. During each period the farm delivers eight grain units; processing converts them into

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seven units of food output and one unit of recoverable residue; and logistics conveys the seven food units to the specified recipient. Agriculture, processing and logistics respectively require two, three and one units of electricity. The resulting joint throughput requirements are collected in Equation 22.

$$\begin{aligned} g_t = 8, \qquad f_t = 7, \qquad c_t = 1, \qquad f_t + c_t = g_t, \\ (e_t^A, e_t^P, e_t^L) = (2, 3, 1), \qquad e_t^A + e_t^P + e_t^L = 6 \leq \overline{E}_t. \end{aligned} \tag{22}$$

Equation 22 is a stylized production recipe; its equality of material-equivalent units is assumed for this example and does not constitute a general physical-conservation law for food processing. Electricity generation has a maximum usable capacity of six energy units in a period whenever its machinery and battery condition satisfy the stated operational thresholds. The farm has sufficient land, water access and other inputs to realize the stipulated eight-unit grain yield, and logistics can transport at least seven units per period. These are capacity and access assumptions, not consequences of near-universal AI labour competence. The producer's output is held constant across monetary and direct-allocation regimes, so that measured differences in payment are not produced by shrinking the required food bundle.

Within the observed boundary, grain and finished-food inventories are separately conserved over delivery events. Let G_t and H_t denote inventories available at the beginning of period t; let p_t be the grain quantity actually consumed by processing and d_t the food quantity actually delivered to the designated recipient. For the constructed zero-inventory schedule, $p_t = 8$, $d_t = 7$ and $(G_1, H_1) = (0, 0)$. Their inventory balance is given by Equation 23.

$$\begin{aligned} G_{t+1} &= G_t + g_t - p_t, \\ H_{t+1} &= H_t + f_t - d_t, \\ (G_1, H_1) &= (0, 0), \qquad p_t = 8, \quad d_t = 7. \end{aligned} \tag{23}$$

The solution is $G_2 = G_3 = H_2 = H_3 = 0$. This convention isolates actual delivery from recorded commitments: an outstanding grain claim could be zero despite delayed final-food delivery if the processing or logistics steps were not independently checked. Here the timing assumptions and independently observed quantities are what make both results agree. The inventory identity also deliberately excludes the ecology and equipment condition indices, which obey different renewal rules.

Three separate regenerative condition stocks. An additional ledger represents three conditions of production: a soil-condition index S_t, an equipment-condition index M_t, and a battery-condition index B_t. These indices have *separate local units* and are not economically interchangeable. In the constructed schedule, production uses one unit of each condition per period. The returned processing residue restores one soil-condition unit; one externally obtained component restores one equipment-condition unit; and one externally obtained battery module restores one battery-condition unit. There is no inference here that a mass unit of compost is physically equivalent to a machine component. Their common numerical increments describe three independent replenishment rules under the assumptions of the example. Equation 24 records these rules.

$$\begin{aligned} \mathbf{h}_{t+1} &= \mathbf{h}_t - \mathbf{w}_t + \mathbf{r}_t, \\ \mathbf{h}_t &= (S_t, M_t, B_t), \qquad \mathbf{h}_1 = (4, 2, 2), \\ \mathbf{w}_t &= (1, 1, 1), \qquad \mathbf{r}_t = (c_t, m_t, b_t) = (1, 1, 1), \qquad t = 1, 2. \end{aligned} \tag{24}$$

Here m_t and b_t are the actually delivered and installed quantities of machine and battery replacements from X. The schedule assumes the operational thresholds $S_t \geq 4$, $M_t \geq 2$ and $B_t \geq 2$ at the beginning of each period. With the deliveries and returns stipulated in Equation 24, $\mathbf{h}_2 = \mathbf{h}_3 = (4, 2, 2)$, so the thresholds hold for both observed production periods and at the following boundary. The recurrence records *material or condition renewal*, not an allocation of generated value to legal or moral claimants. It also exposes the reliance on imported replacements. A soil return that is regenerative within the agricultural circuit coexists with an equipment and battery renewal process that remains open to an external production domain.

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Table 12: Constructed material-feasibility and regenerative-condition ledger for two AI-operated production periods. All numbers are hypothetical; stocks are separate condition indices, not commensurable units of value.

Period	**Grain to processor**	**Food delivered; residue returned**	**Electricity to** A, P, L	**External inputs received**	(S, M, B) **at start and end**
1	8 units	7 food; 1 residue	$(2, 3, 1)$ of 6	1 component; 1 battery	$(4, 2, 2)$ to $(4, 2, 2)$
2	8 units	7 food; 1 residue	$(2, 3, 1)$ of 6	1 component; 1 battery	$(4, 2, 2)$ to $(4, 2, 2)$

Table 12 records the joint physical and temporal results. Each row represents a separate period with the same promised food delivery. The end-stock column orders the indices as soil, machinery and battery and preserves their different units. The table has no monetary prices: the external inputs appear as physical quantities, and their payment classification is evaluated separately.

The regenerative test is meaningful only relative to the explicitly chosen condition variables and the two-period horizon. The model has not independently tracked the ecological effects of water use, mining for replacement components, upstream energy invested in manufacturing batteries, waste-handling burdens beyond the stipulated residue return, or the conditions under which X reproduces its productive capacity. Nor does maintaining three indices at their thresholds establish that all forms of ecological and institutional generation are intact. These omissions are boundaries of the conceptual exercise. Moving the boundary upstream may reveal further monetary obligations and further responsibilities for regeneration.

Rights and outstanding claims. Physical feasibility supplies no authorization to appropriate grain, energy or delivery capacity. For the direct-allocation alternative, assume a governance procedure validates one resource-specific, nontransferable, period-bounded claim for each of the three eligible internal requirements. The grain claim specifies eight units, the electricity claim specifies a six-unit bundle and its recipients, and the logistics claim specifies seven delivered food units. Claims are conditional on their respective capacity and delivery windows; they cannot be sold to a third party or used as general purchasing power. Within the constructed schedule all three are fulfilled in kind during their issuing period. A ledger for each *claim class* k can express issuance, fulfillment and admissible cancellation as in Equation 25.

$$O^k_{t+1} = O^k_t + I^k_t - F^k_t - V^k_t, \qquad k \in \{\text{grain}, \text{power}, \text{delivery}\}. \tag{25}$$

In Equation 25, O^k_t counts outstanding *claims of a particular class*, while I^k_t counts claims newly issued, F^k_t those properly fulfilled, and V^k_t those validly extinguished by a rule-governed procedure other than fulfillment. The equation does not add grain, energy and transport quantities to one another. Set $O^k_1 = 0$, $I^k_t = 1$, $F^k_t = 1$ and $V^k_t = 0$ for the two constructed periods, yielding $O^k_2 = O^k_3 = 0$. The zero balances record the absence of outstanding claims *within those three specified classes*. They do not mean that resource production was costless, that external component suppliers have been paid, or that no other claims or inequalities remain. The legal and normative adequacy of authorization and fulfillment remain distinct assumptions.

Under the monetary baseline, the same internal grain, electricity-bundle and delivery requirements are completed with three monetary payment events per period, and the two replacement procurements from X require two further monetary payments. Under the direct-allocation alternative, the three internal claims are discharged by authorized performance without a generally accepted payment object, while the same two external procurements still require monetary payment. Thus the baseline uses ten monetary payments out of ten eligible tasks across two periods; the alternative uses four out of ten, reproducing the payment-function shares in Table 9. The ledger identifies a *possible* material schedule satisfying the selected requirements, conditional on the specified capacities, deliveries and rights. It does not show that

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the direct-allocation regime is socially optimal, that its claims could never acquire monetary properties, or that its overall monetary dependence equals the payment-task share. For example, if grain entitlements become transferable and repeatedly accepted for unrelated goods, the functional classification must be reconsidered even if conventional payments remain absent.

A missed replacement and the third-period boundary. The capacity to regenerate supplies a simple counterexample to the inference that successful internal circulation guarantees continued independence. Hold period-one deliveries fixed, but suppose X fails to deliver the battery replacement during period two. If no permitted reserve or alternate supply exists and battery wear remains one unit, the resulting condition at the beginning of period three is $B_3 = 1$. This falls below the stipulated threshold $B_t \geq 2$ for the full six-unit electricity schedule. The food-production circuit then lacks an established feasible period-three plan, although all three of its internal period-two resource-specific claims may have been discharged. The interruption might be repaired by a delayed delivery, an independently authorized reserve, a new technical procedure, or procurement using money or other settlement instruments. Which response is available depends on actual capacities and rights. Merely issuing additional credit cannot produce a physically missing battery module.

The stress case makes the temporal and boundary limitations explicit. The two-period result is an example of *bounded operational feasibility*, supported by a continued external procurement relationship and a specified condition-renewal schedule. It is vulnerable to a delayed input whose dependence may have been concealed by an exclusively internal accounting boundary. Under a different resource portfolio the same disturbance could be absorbed without introducing money; under a more constrained portfolio it could trigger emergency monetary procurement or interruption. Stronger AI prediction and shared records could help discover such alternatives, verify available stock and schedule delivery contingencies, subject to physical constraints and institutional authority. Greater knowledge does not itself grant access rights to the required component or resolve competing claims on scarce reserves.

Interpretation for generative return and institutional comparison. The constructed schedule establishes a modest relation among three distinct outcomes. The same seven units of food reach the stipulated recipient in each observed period; the three modeled productive-condition indices return to their initial levels; and the internal payment-function count falls under the alternative while external payments remain. These outcomes are jointly feasible *within the assumptions*. Their conjunction is analytically informative because it prevents reduced monetary payment from being achieved only by silently lowering output or deferring already modeled repair costs. The example offers a locally testable improvement over an account based exclusively on a transaction-count decline.

Generative justice and non-extractive value return require additional questions. Who is entitled to determine the seven-unit delivery priority? Does the residue-return rule appropriately protect land and downstream ecology? Are the external components produced and exchanged under conditions that sustain X and its enabling community? Can T object to a repair policy that transfers uncompensated risk? Can an affected operator challenge the protocol without losing unrelated resource access? The physical recurrence supplies no answer to these normative or institutional questions. Material regeneration is necessary for the stipulated production continuity, but it does not constitute a proof that generated value has returned justly to every contributor. Similarly, the absence of generalized internal payment gives no reason by itself to regard the coordination authority as non-dominating.

The example therefore supports a precise conditional claim: a fixed set of AI-operated production requirements can, under an explicitly feasible two-period physical schedule and adequate rights, shift from monetary payment to resource-specific performance for its internal tasks without changing its stipulated material outputs. The account simultaneously reveals continuing monetary reliance on external maintenance inputs and the possibility of renewed monetary use when those interfaces fail. Whether such arrangements can expand to a much larger set of overlapping production circuits is a separate question of joint capacity, evolving network structure, informational accuracy, contestable authority, and historical regeneration. That broader question motivates the interface analysis below and the independent

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generative-grammar inquiry reserved for Paper III.

A.2 Joint Feasibility of Overlapping Productive Circuits

The bounded food-circuit account above establishes the feasibility of one stipulated production schedule. A network of AI operators may support several recurrent activities that call on the same electricity generator, maintenance facility, or stock of reusable equipment. Such activities cannot be certified independently and subsequently added as though each had an exclusive claim on the shared resource. This subsection constructs a second, overlapping productive circuit in the same two-period horizon and compares two feasible-policy candidates against a common set of service requirements. The aim is to exhibit the difference between the *individual feasibility* of candidate circuits and their *joint material, temporal, and institutional feasibility*. The example is an explicitly assumed finite-horizon construction, not an empirical finding about electrical efficiency or component refurbishment.

A common event set and shared capacity. Let $\mathfrak{C}_t$ denote the candidate productive circuits relevant to a specified period. Different descriptions may traverse the same operator or refer to the same concrete delivery or repair event. To count resources, the planner first constructs a set $\mathcal{J}_t$ of *distinct executable jobs* from the relevant candidate histories, using event identities rather than the number of paths in which those events appear. Job j has an implementation level $z_{jt} \geq 0$ and consumes a_{rj} units of resource type r per unit of implementation. For each resource r, the joint-capacity condition is stated in Equation 26.

$$\sum_{j \in \mathcal{J}_t} a_{rj} z_{jt} \leq K_{rt}, \qquad r \in \mathcal{R}, \quad t \in \{1, 2\}. \tag{26}$$

The K_{rt} are physically available capacities within the stipulated operating windows, not merely nominal entitlements. Distinct units remain typed; a grain requirement cannot compensate arithmetically for missing electricity. A job shared in the descriptions of several circuits enters $\mathcal{J}_t$ once, whereas two physically separate jobs drawing on the same generator enter separately. Joint feasibility additionally requires the prerequisite events and their delivery times, inventory conservation, and permission to use the capacity. Equation 26 is consequently a necessary accounting restriction within the model, not a sufficient account of legitimate or generatively sustainable production. It also explains why an unlimited collection of repeated closed-walk descriptions does not create an unlimited number of separate economic jobs.

Food production and component refurbishment. Consider the original food requirement: eight grain units are processed into seven food units and one recoverable residue unit per period, and all seven food units are transported to the specified recipient. A second circuit takes a worn machine component released by the food operation, refurbishes it using an AI-operated maintenance facility T, and returns one usable component for installation before the next period. Both circuits share electricity operator E and maintenance access. The second circuit is a *candidate condition-renewal circuit*: it is meaningful only if an actual worn component is recovered, an authorized refurbishment process succeeds within its deadline, and the renewed part restores the stipulated equipment-condition unit.

Suppose refurbishment requires two electricity units per period. The food operation in the R30 recipe already uses two units for agriculture, three for processing, and one for logistics, exhausting the six-unit electricity capacity. Its individual feasibility therefore gives no joint certificate for the additional refurbishment operation: the combined electricity demand is eight units while the shared supply is six. The independence error would be to credit the same two energy units as unallocated capacity in the refurbishment loop after already counting them in the food loop. Neither extra credit nor favorable assessments of reciprocity remove that physical shortage.

A possible technical adaptation provides a contrasting construction. Suppose a processing retrofit is already available and legitimately operated at the beginning of period one, and it reduces the food-processing electricity requirement from three units to one while preserving the stipulated grain-to-food

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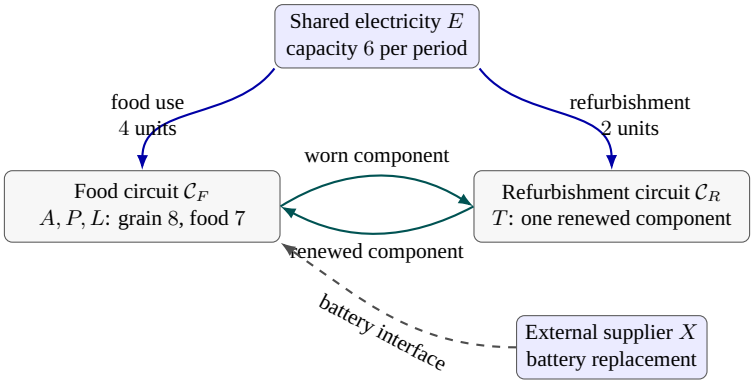

Figure 4: Two overlapping AI-operated productive circuits under the adapted processing recipe. Both require access to one electricity operator. Material renewal moves a worn component to the refurbishment process and returns a usable component; the external battery replacement remains a separate, potentially monetary interface. Arrows describe stipulated deliveries and do not establish rights or fairness.

transformation and its timing. These performance numbers are assumptions of the counterfactual, with no empirical basis claimed. The food process then needs four electricity units in total, leaving two for refurbishment. The capacity test for the adapted joint schedule is stated in Equation 27.

$$\begin{aligned} &e_t^F = e_t^A + e_t^P + e_t^L = 2 + 1 + 1 = 4, \\ &e_t^R = 2, \qquad e_t^F + e_t^R = 6 \le \overline{E}_t = 6, \qquad t = 1, 2. \end{aligned} \tag{27}$$

Here e_t^R is the distinct refurbishment job's electricity requirement. The retrofit changes a technical coefficient; it does not manufacture additional electricity. The two-period schedule further assumes sufficient refurbished-part transport, that the worn part is available before the relevant repair window, and that T can complete one refurbishment and one battery-installation service per period within a two-slot service capacity. Under the original imported-component recipe, the same two maintenance slots suffice for installing one purchased machine component and one purchased battery. An unmodeled retrofit installation cost, additional maintenance wear, or shortage of a necessary refurbishment consumable would change the comparison and must be added to the relevant boundary before any longer-horizon claim.

Figure 4 identifies the shared electricity constraint and the component-return interface. The illustration intentionally distinguishes the food output from the returning reusable part. It does not imply that the return of a refurbished part and the delivery of food are interchangeable values, or that the two circuits possess independent ownership of E.

Temporal stocks and regenerative thresholds. The adapted schedule keeps the R30 end-use requirement unchanged: seven food units are delivered and one residue unit is returned in each period. The new material item is the worn component. Let W_t be its available inventory at the beginning of period t, u_t the number of worn components recovered after production, and r_t the number actually refurbished during the period and installed before the following period. Let S_t, M_t, B_t retain their separate condition-index meanings. The two-period renewal account is given in Equation 28.

$$\begin{aligned} W_{t+1} &= W_t + u_t - r_t, & W_1 &= 0, \\ S_{t+1} &= S_t - 1 + c_t, & S_1 &= 4, \\ M_{t+1} &= M_t - 1 + r_t, & M_1 &= 2, \\ B_{t+1} &= B_t - 1 + b_t, & B_1 &= 2, \\ (u_t, r_t, c_t, b_t) &= (1, 1, 1, 1), & t &= 1, 2. \end{aligned} \tag{28}$$

The one-unit recovery and refurbishment in Equation 28 are possible under the stipulated sequencing: the production activity releases the component, refurbishment occurs afterward using its reserved elec-

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Table 13: Joint-capacity and monetary-payment comparison for two hypothetical AI production regimes across the same two-period functional-service horizon.

Comparison dimension	**Original food circuit**	**Adapted food and refurbishment circuits**
Food output and residue, per period	7 food; 1 residue	7 food; 1 residue
Electricity allocation, per period	6 food; 0 refurbishment	4 food; 2 refurbishment
Electricity capacity, per period	6 units	6 units
Maintenance-service demand, per period	2 installation slots	1 refurbishment; 1 installation slot
Machinery-condition renewal	1 externally purchased component	1 internally refurbished component
Battery-condition renewal	1 externally purchased module	1 externally purchased module
Monetary uses per five functional slots	5	1
Modeled third-period condition state	$(4, 2, 2)$	$(4, 2, 2)$

tricity and maintenance slot, and installation is completed before the next period. The example assumes complete recovery and no irreversible loss of refurbishability over the two observed periods. This is a particularly strong materials assumption: a physical refurbishment system generally requires attention to component degradation, supplies, wastes and eventual replacement. Accordingly, the recurrence is a *two-period illustrative witness* and supplies no claim of perpetual material closure. The battery module is still purchased from the external supplier and installed before the next period.

Under these assumptions, $W_2 = W_3 = 0$ and $(S_t, M_t, B_t) = (4, 2, 2)$ at the beginning of $t = 1, 2, 3$. The grain and food inventories follow Equation 23; the food output remains seven units per period. Feasibility is conditional on the joint electricity allocation, the two maintenance slots, usable component recovery, the stipulated processing retrofit, time-respecting transfers, and authorized access to each shared service. If refurbishment fails in period two, then $r_2 = 0$ and $M_3 = 1$, below the normal-operation threshold. Returning a promise to the maintenance ledger would not restore the machine's physical condition; emergency import of a replacement component might make an additional monetary payment necessary.

Comparable services and changing transaction identities. An institutional comparison can hold the same five *functional service requirements* fixed within each period: grain provision, electricity dispatch, food delivery, machinery-condition renewal and battery-condition renewal. Their physical implementation and provenance are allowed to differ. Under the original food schedule, the first three are internal monetary payment tasks, while the machinery and battery renewals are external monetary procurements. Under the adapted overlap schedule, the first four functions use period-specific nontransferable internal entitlements and actual performance, whereas battery renewal still relies on an external monetary payment. The electricity service includes the four-unit food dispatch and the two-unit refurbishment reservation as one jointly authorized six-unit schedule. Refurbishment is counted as the *machinery-renewal* function and cannot also be counted as a separate sixth slot without altering the denominator.

Table 13 compares the two arrangements under these accounting conventions. The resulting two-period payment-use share in the adapted regime is $2/10$, compared with $10/10$ in the original all-payment baseline. The previous R30 direct-allocation alternative, which retained externally purchased machine parts, had $4/10$ monetary payment tasks. These fractions refer to the *five explicitly defined functional requirements per period*, not to a complete economy's transaction count or the share of resource value mediated by money. Importantly, the newly introduced refurbishment changes the identities of underlying jobs and their resource costs. If tasks are classified by individual contractual exchanges rather than fixed functional service requirements, their number and the reported share must be recalculated. The comparison therefore provides a conditional function-level illustration, not an invariant index independent of the counting convention.

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The comparison has two further limitations. First, the processing retrofit is given as a pre-existing technical capability in the adapted regime. Its installation costs, property rights, and resource history are outside the displayed two-period horizon. A full evaluation of historical monetary dependence would include those earlier expenditures, and a longer simulation might discover further maintenance requirements. Second, the assumed resource-specific internal claims are issued by an authorized allocation procedure but are not independently proven just. Both circuits may be materially sustainable over the observed window while a governance authority exercises arbitrary exclusion, an upstream supplier bears uncompensated burdens, or one operator lacks a fair opportunity to challenge the schedule. Shared data and stronger AI prediction improve possible verification of the material case; they do not decide the governing principles.

Implications for circuit composition and monetary boundaries. The additional refurbishment circuit supplies a more demanding test than checking whether two loops are visibly closed on a graph. The original electricity-capacity bottleneck renders their naive superposition infeasible. A specified alteration in production technique changes their common feasible set without eliminating resource scarcity. Once the processes are jointly schedulable, the refurbishment service can replace an external monetary procurement for machinery-condition renewal while the battery interface remains monetary. Thus a local reduction in monetary payment can accompany the formation of a new internally supported resource cycle. The result is conditional on technical improvement, resource accounting, execution timing, the rights under which the relevant jobs are authorized, and the finite-horizon possibility of material renewal.

The example also draws the boundary of a claim that advanced AI might improve production coordination. Improved network inference can detect the eight-unit bottleneck, identify the two-unit processing-efficiency opportunity, verify component reuse, and schedule the jointly feasible jobs. These are consequential epistemic and operational improvements. Their realization depends on available technology, valid rights and reliable observations. Neither perfect enumeration of closed walks nor global monetary abolition is a prerequisite for the particular adapted schedule. The general generation and recognition of nested circuits remains a separate formal-grammar problem reserved for Paper III; within the present paper, the finite counterexample and witness demonstrate how overlapping value-circuit proposals must be assessed as a shared resource portfolio.

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A.3 Intertemporal Durability, Reinvestment, and Priority in Shared-Resource Circuits

The joint-capacity witness in Subsection A.2 holds for two periods under a fully recoverable component and an already installed processing retrofit. An assessment of monetary substitution over a longer horizon must distinguish repeated services from the repeated use of an unchanged material object, disclose the origin and renewal of repair capability, and specify what happens when several authorized circuits compete for insufficient capacity. The following four-period extension gives a bounded durability counterexample to indefinite circularity and a conditional repair-and-reinvestment schedule. Its numbers remain constructed assumptions. Its purpose is to test the internal implications of the earlier witness, not to estimate industrial recovery rates, optimal service life, or a future AI economy.

Finite component reuse and inherited technical conditions. Retain the food bundle of seven units and the associated one-unit residue return, with four electricity units allocated to farming, efficient processing, and logistics each period. A refurbished machine component restores one unit of machinery condition. For the four-period extension, assume an installed component can be refurbished at most twice under the particular recovery technology, after which the next worn component must be replaced by a newly supplied one. This is a stipulated finite-use boundary; another technology could support a different limit. Let q_t record the number of prior refurbishments of the component in service at the beginning of period t. Let r_t be a completed internal refurbishment and m_t an externally acquired replacement, each taking values in $\{0, 1\}$. The operational replacement requirement and renewal-count

update are stated in Equation 29.

$$\begin{aligned} &r_t + m_t = 1, && r_t \le \mathbf{1}_{\{q_t<2\}}, \\ &q_{t+1} = \begin{cases} q_t + 1, & r_t = 1, \\ 0, & m_t = 1, \end{cases} && q_1 = 0, \qquad t = 1, \dots, 4. \end{aligned} \tag{29}$$

Here **1** denotes an indicator of the stated condition. The admissible schedule $r = (1, 1, 0, 1)$, $m = (0, 0, 1, 0)$ yields $q = (0, 1, 2, 0)$ at the respective period starts and $q_5 = 1$. In particular, the component imported in period three begins a new material history; its acquisition is an external transaction and does not become a free consequence of the original two-period loop. The two refurbishment operations in periods one and two reproduce the assumptions of the earlier example, while period three exposes the point at which its full-recovery simplification would fail if extrapolated without amendment.

A separate condition index K_t records available repair-tool service capacity. The extension assumes that each refurbishment uses one unit of this tool condition, with $K_1 = 2$. An external renewal service delivers $k_3 = 2$ units of repair-tool condition in period three, after the period-three production and before period four; all other k_t are zero. Repairs require available tool condition at their time of execution. Equation 30 gives the bounded inventory rule.

$$\begin{aligned} &K_{t+1} = K_t - r_t + k_t, && K_1 = 2, \\ &K_t \ge r_t, && (k_1, k_2, k_3, k_4) = (0, 0, 2, 0). \end{aligned} \tag{30}$$

It follows that the opening tool states are $(K_1, K_2, K_3, K_4) = (2, 1, 0, 2)$ and $K_5 = 1$. The condition index is a bookkeeping representation of stipulated service capability, not a claim that repair equipment can be restored by adding physically identical units. The starting stock K_1 is historically inherited and requires an origin account in any full assessment. The period-three tool renewal incurs a separate external obligation; it cannot be hidden within the count of machine-component renewal or treated as free merely because the visible repair transaction is internal.

The material-condition rules in Equation 28 generalize in this extension by replacing its constant refurbishment input with the actual combined machinery replacement $r_t + m_t = 1$. Soil and battery renewal continue to be modeled separately: $c_t = 1$ residue unit returns each period, and one external battery module $b_t = 1$ is delivered for each next-period operating cycle. Their condition-index updates remain $S_{t+1} = S_t - 1 + c_t$, $M_{t+1} = M_t - 1 + (r_t + m_t)$, and $B_{t+1} = B_t - 1 + b_t$. These recurrences preserve $(S_t, M_t, B_t) = (4, 2, 2)$ through the four observed periods under timely deliveries; the tool state in Equation 30 is an additional independent feasibility constraint. The grain and food balances in Equation 23 likewise retain seven delivered food units each period. These conclusions remain conditional on the originally stipulated land, water, energy generation, logistics, and authorization assumptions.

Joint scheduling and the priority of shared inputs. The refurbished component requires two electricity units when $r_t = 1$. Period-three external component replacement does not use those two refurbishment units. Let e_t^F be the food-circuit electricity requirement, e_t^R the repair-circuit allocation, and e_t^U the uncommitted remainder. The period-by-period electricity feasibility identity is Equation 31.

$$e_t^F = 4, \qquad e_t^R = 2r_t, \qquad e_t^U = 6 - 4 - 2r_t \ge 0, \qquad t = 1, \dots, 4. \tag{31}$$

The adapted schedule consequently requires six electricity units in periods one, two, and four and four in period three; the period-three two-unit remainder is available capacity, not proof of a costless benefit or independently generated value. At most two maintenance-service slots are used in each period: one to install the battery and one to refurbish or install the machinery component. These services also have deadlines. For example, a component delivered after the beginning of period four would fail to support the stated fourth-period operating condition even if a cumulative ledger eventually balanced.

The electricity identity is an engineering feasibility test. It does not determine who may set allocation priorities when capacity falls below six. Suppose actual electricity availability in period two is

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Table 14: Constructed four-period durability and monetary-interface ledger for overlapping AI-operated circuits. Functional payment uses cover five fixed services per operating period; tool renewal and the period-zero retrofit are additional obligations.

Variable or event	$t = 1$	$t = 2$	$t = 3$	$t = 4$
Grain input and food delivery	8, 7	8, 7	8, 7	8, 7
Food/repair electricity units	$4 + 2$	$4 + 2$	$4 + 0$	$4 + 2$
Machine-condition renewal	Reuse	Reuse	Import	Reuse
Refurbishment count at opening q_t	0	1	2	0
Repair-tool condition at opening K_t	2	1	0	2
External battery purchase	1	1	1	1
External repair-tool renewal	0	0	1 service	0
Monetary uses in five fixed services	$1/5$	$1/5$	$2/5$	$1/5$

five units while the food circuit requires four and refurbishment remains a two-unit indivisible task. Allocating four units to food leaves one unit, insufficient for the stipulated refurbishment; allocating two to refurbishment leaves only three, below the stated food-production recipe. A candidate priority rule could protect a specified essential-food obligation, trigger an emergency component-import request, and open a review process for affected participants. Another legitimate rule might allocate differently under different rights and needs. In this example, preserving the four-unit food allocation without procuring the delayed machinery renewal would produce $M_3 = 1$, violating the normal-operation threshold of two at the start of period three. The priority decision and its external fallback therefore have observable material consequences, but their justice depends on the provenance of entitlements, urgency, burden sharing, and available avenues of appeal.

A centralized scheduler could also guarantee throughput by overriding the maintenance operator's refusal to participate. Material continuity would then coexist with a possible increase in domination. Conversely, a protected refusal could occasion a real but temporary loss of productive capacity while allowing a justified dispute over burdens or maintenance safety to be heard. The example accordingly treats priority, substitution, and review as coupled institutional constraints. More accurate AI forecasts may identify the impending five-unit shock and compute alternative schedules, yet the authority to suspend or reallocate an operator's claim remains a distinct normative problem.

Accounting for the acquisition of the retrofit and repair capability. The energy-efficient processing recipe used by the adapted circuit presupposes a technical intervention. Let period zero denote the installation period of the processing retrofit. Assume, solely for the extended thought experiment, that acquiring the retrofit entails one monetary purchase of a specialized module, together with an authorized installation service and production inputs whose quantities and origin require separate accounting. The operating comparison in Table 13 begins at period one and correctly excludes this preliminary purchase only when its time boundary is stated. In an expanded historical account, the purchase and its upstream productive conditions reappear. The same observation applies to the inherited repair-tool stock K_1 and to the external tool renewal in period three.

Table 14 records the constructed four-period schedule. The table counts external battery-module purchases in each period, the new machinery component in period three, and the repair-tool renewal service in that same period. Only the first two categories belong to the five fixed functional service requirements originally used to construct the period-level monetary-use indicator. The tool renewal is an additional upstream service made visible by enlarging the production boundary. The period-zero retrofit is a further acquisition outside the four-period service denominator. The distinct counting bases are essential: a fixed-function usage fraction describes a chosen boundary, while a complete intertemporal account must also record enabling activities that were previously inherited or unobserved.

Under this explicit accounting, the original all-payment benchmark would employ twenty monetary payments for twenty named functional services over four periods; the adapted arrangement employs five such payments over the same twenty service functions, assuming all stipulated deliveries and authoriza-

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tions. The associated function-level usage shares are $20/20$ and $5/20$. They are descriptive fractions of a stipulated task set. The adapted regime also includes the separate monetary repair-tool renewal service in period three and the period-zero retrofit acquisition, making seven explicitly counted monetary acquisition or service events across the expanded observation history. The inherited repair equipment, the new module's upstream production, and unpriced governance and ecological obligations remain outside that event count. Consequently, neither the function-level fraction nor the seven events support a claim about total monetary expenditure, monetary dependence across all functions, welfare gains, or the absolute efficiency of one regime relative to another.

A cost comparison would additionally require the retrofit's monetary price or resource cost, the repair-tool service cost, component and battery acquisition costs, energy opportunity costs, time discounts, authorized transfer rights, waste handling, and the ecological history of each input. These quantities are heterogeneous. Converting them into a scalar objective requires explicit and contestable valuation conventions. Even if fewer external payments occur, the new circuit can be materially more expensive, ecologically damaging, or normatively less defensible. This paper therefore evaluates the constructed example through a vector of distinct questions: material and temporal feasibility, renewal of critical productive conditions, payment-function use at the declared boundary, distribution of maintenance and upstream costs, and legitimate authority over priority allocation.

Intertemporal robustness and the limits of circuit closure. The four-period schedule demonstrates that a longer observation horizon may reveal external obligations masked by a two-period material return. Period three forces a new component purchase under the assumed finite refurbishment limit, while repair-tool capacity needs a separately supplied renewal. If the new component or external battery does not arrive before the next operating deadline, the respective condition threshold can fail even if all internal accounting claims are otherwise settled. If the retrofit becomes unavailable or loses effectiveness, food operations again require the six-unit original electricity bundle, removing the adapted two-unit room for refurbishment. These possibilities expose historically specific dependencies that an apparent static cycle cannot represent.

A stronger sustainability claim would require a feasible control and resource-reproduction policy over an explicitly defined longer horizon, with shocks, degradation, replacement input provenance, and institutional revision procedures. The candidate schedule would also have to specify how affected parties may contest priorities and how the relevant decision-makers are held accountable. A single successful finite-horizon portfolio is a useful feasibility witness under its assumptions; extending it to indefinite operation would require additional assumptions or proof about invariant feasible sets, exogenous supplies, and recoverable production conditions. The present thought experiment retains this distinction deliberately. It offers a case in which local monetary functions are partially substituted as production circuits are reconfigured, while displaying concrete points at which money-like claims, external purchases, new power concentrations, and disputed priorities may continue or reappear.

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References

[1] Elizabeth Anderson. *Value in Ethics and Economics*. Harvard University Press, Cambridge, MA, 1993.

[2] W. Brian Arthur. Competing technologies, increasing returns, and lock-in by historical events. *The Economic Journal*, 99(394):116–131, 1989.

[3] Cristina Bicchieri. *The Grammar of Society: The Nature and Dynamics of Social Norms*. Cambridge University Press, 2006.

[4] Steven L. Brunton, Joshua L. Proctor, and J. Nathan Kutz. Discovering governing equations from data by sparse identification of nonlinear dynamical systems. *Proceedings of the National Academy of Sciences*, 113(15):3932–3937, 2016.

[5] Sergey V. Buldyrev, Roni Parshani, Gerald Paul, H. Eugene Stanley, and Shlomo Havlin. Catastrophic cascade of failures in interdependent networks. *Nature*, 464(7291):1025–1028, 2010.

[6] Ron Eglash, Kwame P. Robinson, Audrey Bennett, Lionel Robert, and Mathew Garvin. Computational reparations as generative justice: Decolonial transitions to unalienated circular value flow. *Big Data & Society*, 2024.

[7] Richard M. Emerson. Power-dependence relations. *American Sociological Review*, 27(1):31–41, 1962.

[8] Ernst Fehr and Klaus M. Schmidt. A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics*, 114(3):817–868, 1999.

[9] Michel Foucault. The subject and power. *Critical Inquiry*, 8(4):777–795, 1982.

[10] Andrea Gabrielli, Diego Garlaschelli, Subodh P. Patil, and M. Ángeles Serrano. Network renormalization. *Nature Reviews Physics*, 7:203–219, 2025.

[11] Hannah Ginsborg. Kant's aesthetics and teleology. In Edward N. Zalta and Uri Nodelman, editors, *The Stanford Encyclopedia of Philosophy*. Metaphysics Research Lab, Stanford University, fall 2022 edition, 2022.

[12] Grassroots Economics Foundation. Commitment pooling and community vouchers: A field guide. Grassroots Economics Documentation. Online training guide, accessed 8 October 2026.

[13] Grassroots Economics Foundation. Commitment pooling: Frequently asked questions. Grassroots Economics Documentation. Online documentation, accessed 8 October 2026.

[14] Albert O. Hirschman. *Exit, Voice, and Loyalty: Responses to Decline in Firms, Organizations, and States*. Harvard University Press, Cambridge, MA, 1970.

[15] Petter Holme and Jari Saram"aki. Temporal networks. *Physics Reports*, 519(3):97–125, 2012.

[16] Donald B. Johnson. Finding all the elementary circuits of a directed graph. *SIAM Journal on Computing*, 4(1):77–84, 1975.

[17] Leo Katz. A new status index derived from sociometric analysis. *Psychometrika*, 18(1):39–43, 1953.

[18] Mikko Kivel"a, Alex Arenas, Marc Barthélemy, James P. Gleeson, Yamir Moreno, and Mason A. Porter. Multilayer networks. *Journal of Complex Networks*, 2(3):203–271, 2014.

[19] Nobuhiro Kiyotaki and Randall Wright. On money as a medium of exchange. *Journal of Political Economy*, 97(4):927–954, 1989.

[20] Narayana R. Kocherlakota. Money is memory. *Journal of Economic Theory*, 81(2):232–251, 1998.

[21] Narayana R. Kocherlakota and Neil Wallace. Incomplete record-keeping and optimal payment arrangements. *Journal of Economic Theory*, 81(2):272–289, 1998.

[22] Yang-Yu Liu, Jean-Jacques Slotine, and Albert-László Barabási. Observability of complex systems. *Proceedings of the National Academy of Sciences*, 110(7):2460–2465, 2013.

[23] Ramon Marimon, Ellen McGrattan, and Thomas J. Sargent. Money as a medium of exchange in an economy with artificially intelligent agents. *Journal of Economic Dynamics and Control*, 14(2):329–373, 1990.

[24] Elinor Ostrom. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press, 1990.

[25] Elinor Ostrom. Beyond markets and states: Polycentric governance of complex economic systems. Nobel Prize Lecture, 8 December 2009, 2009.

[26] Philip Pettit. *Republicanism: A Theory of Freedom and Government*. Oxford University Press, Oxford, 1997.

[27] Edella Schlager and Elinor Ostrom. Property-rights regimes and natural resources: A conceptual analysis. *Land Economics*, 68(3):249–262, 1992.

[28] Bernhard Schölkopf, Francesco Locatello, Stefan Bauer, Nan Rosemary Ke, Nal Kalchbrenner, Anirudh Goyal, and Yoshua Bengio. Toward causal representation learning. *Proceedings of the IEEE*, 109(5):612–634, 2021.

[29] Amartya Sen. *The Idea of Justice*. Harvard University Press, Cambridge, MA, 2009.

[30] Kenneth N. Waltz. *Theory of International Politics*. Addison-Wesley, Reading, MA, 1979.

[31] Duncan J. Watts. A simple model of global cascades on random networks. *Proceedings of the National Academy of Sciences*, 99(9):5766–5771, 2002.

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