

Criticality or Controllability?

The Historical Evolution of Generative Landscapes
A Preliminary Inquiry in Relational Governance Economics

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Abstract

The apparent choice between criticality and controllability arises when a participant in an established relational system must consider both disturbance-related losses and the costs of becoming locked into a stable path. The present discussion draws on established nonlinear dynamics, constrained control, evolutionary economics, and institutional path-dependence research to examine this tension without positing a universal priority between the two. Effective control capacity is specified relative to an actor, an admissible task, information, resource constraints, and a time horizon. An illustrative control model clarifies why the ability to maintain a current arrangement can differ from the ability to transform it. The inquiry then considers how organisational routines, authority, learning, and participation across several relational systems may change these capacities and the conditions for feasible transitions. The provisional term *generative landscape* refers to the historically conditioned possibilities and costs accessible to situated actors, including their unequal distribution. The paper offers an interpretive framework and questions for comparative inquiry, not original empirical findings or a validated model of institutional dynamics. No conceptual novelty or intellectual priority is claimed.

Keywords: criticality; effective control capacity; evolutionary economics; relational governance; generative landscapes

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Suggested citation. Huang, W. (2026). *Criticality or Controllability? The Historical Evolution of Generative Landscapes: A Preliminary Inquiry in Relational Governance Economics*. Independent discussion paper, circulation version 1.0 (16 October 2026). Unreviewed manuscript; cite the version used.

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1 Introduction

An actor entering or remaining within an established organisation may face a practical governance tension. Greater influence over tasks, resources, and decisions can protect continued participation, yet the same arrangement may limit opportunities to revise a professional or institutional trajectory. Conversely, participation in a more changeable setting may support exploration while exposing the actor to disturbances that are costly to absorb. In relationships characterised by unequal authority, these concerns extend beyond preference for security or novelty: the participants may differ in who can introduce a disturbance, who is obliged to respond, and who can alter the rules by which the resulting costs are allocated. The opening question of this discussion paper is therefore deliberately limited: how should criticality and controllability be understood when both their conditions and their consequences may change over time?

The term *controllability* requires care in such a setting. Formal decision rights, effective influence over current activity, and the ability to change an institution's rules are distinct. An actor may arrange daily work while remaining unable to refuse an additional obligation, obtain adequate resources, or make an economically feasible exit. Throughout this paper, *effective control capacity* refers provisionally to the feasible influence of a specified actor over a specified dynamical or practical task, given available information, institutional permissions, resources, and time. This usage is task-relative and does not purport to replace the mathematical definitions of controllability. Two tasks will be especially relevant: regulating disturbances within a current arrangement and participating in a change of the arrangement's conditions. Section 2 gives the corresponding formal conventions and their limits.

Criticality also has a restricted technical meaning. A bifurcation or critical transition concerns a defined change in the behaviour of a dynamical system under specified conditions. In some models, response to disturbance and recovery near a transition may change markedly; the existence and diagnostic value of such effects depend on the mechanism and observations [13]. In organisational life, experimentation, institutional flexibility, and the emergence of new relationships are more general descriptions. They should not be classified as instances of mathematical criticality without identifiable states, dynamics, and evidence. The paper accordingly keeps *criticality* distinct from *openness to relational reconfiguration* and from *generativity*. It examines possible connections among them rather than treating them as synonyms.

One possible vulnerability arises when the capacity to regulate disturbances falls short of the exposure imposed by a relationship. Unanticipated assignments, shifts in access to resources, or changing conditions of participation may require repeated expenditure of time, income, attention, and organisational goodwill. An organisation may remain functional while a participant's capacity to continue is gradually depleted. For present purposes, *dissipation* names this context-dependent expenditure or loss of socioeconomic resources, not a thermodynamic identity between institutions and physical systems. The central question is the relation among disturbance, available intervention, replenishment, and who bears their costs. A changeable environment can be valuable for learning, but high responsiveness by itself establishes neither a benefit nor a sustainable capacity to respond.

A second vulnerability may arise through stabilisation. Reliable rules, sustained income, professional expertise, and repeated coordination can support learning, care, and commitments that would otherwise be difficult to maintain. Under some conditions, the same accumulation can increase dependence on a particular institutional path. Specialised skills, commitments to others, and diminishing access to external relationships may raise the cost of a later transition, even while competence in existing tasks increases. Studies of increasing returns and path dependence show how particular trajectories may be reinforced by historically contingent sequences [1, 12]. The relevant mechanism must nevertheless be demonstrated in each case: stability alone does not establish lock-in, and the cost of change need not increase monotonically or become irreversible.

These two vulnerabilities do not constitute an exhaustive classification or a fixed trade-off. Protection from disturbance may create resources for experimentation. Participation in exploratory work may develop knowledge, collaborators, and new means of regulation. Equally, expanded authority within current routines may coexist with weak influence over institutional rules, and a wider nominal choice

set may coexist with diminishing resources for exercising it. The comparison must therefore identify the actor, the task, the relational configuration, the horizon, and the feasible means of change. The costs of maintaining a present arrangement and the costs of transforming it may follow different histories.

Evolutionary economics offers an established language for those histories. Nelson and Winter analyse organisational routines, search, and selection as elements of economic change [10]; Dosi situates technological trajectories within evolving scientific, economic, and institutional conditions [4]. These accounts caution against treating current choices as if they were made within a permanently fixed set of feasible alternatives. For a governance inquiry, a change in resources or permissions may alter what an actor can do; the ensuing interactions may affect organisational routines and alliances; those alterations may then reshape the actor's later capacities and obligations. Control, vulnerability, and opportunities for reconfiguration can thus be linked through historical feedback without a universally given order of precedence. This paper draws on such pre-existing traditions and makes no claim to have originated the underlying insights.

The historical comparison also changes when the focal actor participates in several relational systems. An arrangement that provides dependable income and limited discretion may coexist with another that supports research, skill development, or collaboration. A relatively exploratory affiliation may instead be supplemented by independent financial or institutional support. In either sequence, opportunities within one relationship can affect the resources available in another. Work on polycentric governance provides a related precedent for considering the learning and coordination possibilities of multiple decision centres, although an individual's portfolio of affiliations is not itself a polycentric public-governance regime [11]. Parallel participation can involve conflicting duties, unportable knowledge, correlated risks, or exhaustion of shared resources. Whether complementarity occurs is a question about the particular connections among systems, not an automatic benefit of their number.

The provisional expression *generative landscape* is used to bring these observations into one bounded analytical view. Here it denotes the historically formed, actor-relative configuration of feasible activities and relations, available capacities, institutional constraints, costs, and possible transitions. It is a description of conditions to be investigated, not a claim that institutions possess a single measurable fitness surface. A landscape can change through learning, bargaining, rule revision, cooperation, and the loss or formation of connections. Its evolution is not necessarily beneficial: a newly feasible path for one actor may transfer costs to others, and the persistence of a successful organisation may depend upon unsustainable burdens borne by its members. The relevant governance inquiry therefore includes both the accessibility of possible futures and the distribution of authority, benefits, and losses across participants.

This account also distinguishes descriptive possibility from normative value. A transition's feasibility does not establish that it is fair, lawful, or desirable; an institution's stability does not establish the legitimacy of its power relations. Similarly, a simple control model may represent another actor's decisions as disturbances for a restricted task, but such a representation cannot settle questions of consent, justification, or reciprocal obligation. The paper approaches these matters as questions requiring historical and institutional evidence, interpretive care, and, where appropriate, separate normative argument. Technical concepts supply useful restrictions on our claims when their assumptions are stated; they do not certify an empirical dynamical model of social reality. Constrained viability offers one example of an established mathematical problem to which a restricted governance model might be compared [2].

The following sections develop the argument at this limited scale. Section 2 introduces the necessary dynamical vocabulary and a task-relative account of effective control capacity. Section 3 examines possible costs of regulation and historical lock-in. Section 4 considers how capacities and conditions of structural change evolve together. Section 5 examines cross-system relations and specifies the landscape vocabulary. Section 6 returns to governance implications, evidential limits, and the opening question. The manuscript is an exploratory discussion rather than an empirical institutional study, a validated model, or a prescription of an optimal balance. It claims no conceptual novelty or intellectual priority for its terms, mechanisms, interpretations, or their combination. Its aim is to make more precise a question about historical choice: how can present relational practices affect the conditions under which later choices become possible, costly, or inaccessible?

2 Dynamical Background and Effective Control Capacity

This section specifies the limited dynamical vocabulary required to examine criticality and controllability in a historical relational setting. Its first task is to distinguish mathematically defined stability, attraction, and transitions from broader claims about the generation of social possibilities. Its second is to define effective control capacity relative to an actor, a task, and the actual conditions under which intervention is feasible. Its third is to connect that definition to constrained reachability, viability, and resource expenditure. The formal constructions are deliberately minimal: they organise the questions pursued in subsequent sections and do not constitute an empirically identified model of any particular institution.

2.1 Nonlinear Dynamics, Attractors, and Critical Transitions

A dynamical model specifies how a state changes over time. In a discrete-time model, a state x_t is mapped to a subsequent state; in a continuous-time model, a vector field specifies its local rate of change. Nonlinearity means that the relevant evolution law does not generally preserve linear combinations of states or inputs. The resulting behaviour can include multiple stable regimes, changes in the qualitative structure of trajectories, and sensitivity to initial conditions or disturbances. These are possibilities of particular nonlinear models rather than properties of every nonlinear system. Standard treatments distinguish equilibria, their stability, attractors, bifurcations, and feedback control with substantially greater precision than is available from the corresponding social metaphors [15, 6].

An *attractor* is, in an appropriate dynamical-system setting, an invariant set that attracts trajectories from a neighbourhood or a specified set of initial conditions. Its *basin of attraction* comprises initial states whose trajectories approach it. The attracting set need not be a single fixed point: oscillatory or more complicated attractors are also possible. Stability and attraction should therefore be kept distinct from an institution's apparent endurance. A recurring organisational routine may be an empirical instance of reproduction through incentives and coordinated expectations; calling it an attractor becomes a mathematical claim only after one defines a state space, an evolution law, and a relevant notion of attraction. Further, a time-varying institutional environment may fail to satisfy the autonomous conditions under which a simple fixed attractor is defined.

A *bifurcation* describes a qualitative change in a dynamical system's behaviour as a parameter varies. The familiar language of *critical transition* is associated with some such changes, including transitions in which a previously stable regime loses resilience. The loss of stability may be preceded by slower recovery from perturbations in certain models, but the presence or absence of such an indicator depends on the mechanism and observations; no universal early-warning signature follows merely from calling a system critical [13]. Likewise, hysteresis is a history-dependent response in which reversal of a parameter change need not retrace the original transition. It can arise from multistability under specified mechanisms and should not be inferred from path dependence alone.

The scalar system in Equation 1 illustrates the narrow sense in which some of these terms can be assigned explicit meaning.

$$\dot{q} = \mu q - q^3 + bu + w. \quad (1)$$

Here q is a stylised state, μ is a parameter, u a control input, b its effectiveness, and w an external perturbation. For the unforced case $u = w = 0$, a negative μ yields a locally attracting equilibrium at $q = 0$; a positive μ yields two attracting equilibria at $q = \pm\sqrt{\mu}$ and an unstable equilibrium at zero. The symmetric model undergoes a pitchfork bifurcation at $\mu = 0$. The example illustrates changes in stability and attraction while making no statement about a social institution's actual state variables, parameter values, or likelihood of a transition. In particular, this symmetric example does not itself establish a hysteresis mechanism, and adding an intervention changes the relevant system.

Three conceptual separations are important for the present inquiry. First, *stability* concerns persistence or recovery under a specified evolution law; it is not a direct measure of an actor's freedom or welfare. Second, *criticality* has a technical meaning only relative to identified dynamical properties and parameters. A comparatively open setting with frequent experimentation need not lie near a math-

emational bifurcation. Third, *generativity*, as provisionally discussed here, concerns the formation and transformation of feasible activities, relations, and future conditions. A technically critical transition can eliminate possibilities, while a stable arrangement can support new knowledge and cooperative forms. Any translation among these concepts requires an independently justified mechanism and attention to the actors for whom consequences are assessed.

2.2 A Task-Relative Definition of Control Capacity

The term *controllability* has established technical meanings in control theory. In particular, reachability and controllability concern state transfers under permitted inputs, while stabilisation concerns maintaining or approaching desired behaviour through suitable control laws [14]. For a governance discussion, a claim that an actor “has control” is underspecified unless the controlled object, accessible actions, objectives, time horizon, disturbances, and resources are identified. An actor may be able to preserve a routine yet have little influence over the rules that reproduce that routine. Conversely, an actor may possess credible avenues of institutional revision while having limited discretion over day-to-day events. The relevant capacities are task-dependent and should not be collapsed into an undifferentiated scalar attribute of power.

The present paper uses *effective control capacity* in the following stipulated and limited sense.

Definition 2.1 (Task-relative effective control capacity). For a specified actor a , initial relational configuration, target or maintenance task, time horizon, admissible disturbances, information available to the actor, and resource constraints, effective control capacity is the actor’s ability to implement an admissible, non-anticipative policy that fulfils the task under the stated conditions. The ability is assessed relative to the feasible interventions actually available through the actor’s material resources, skills, institutional permissions, and relationships, together with the causal effects of those interventions on the relevant system.

Definition 2.1 gives a conditional assessment rather than a new measure of political power or a claim of conceptual novelty. It requires a distinction between *formal authority*, the permissions allocated by rules or organisational position, and *effective intervention*, the capacity to influence an outcome under the conditions that obtain. Decision rights may be unenforceable, resources may be insufficient, or the response of other actors may neutralise a proposed intervention. Conversely, informal support, specialised knowledge, rights of refusal, or credible alternatives outside an organisation may enlarge the feasible set of effective actions without changing a person’s official title. These are candidate mechanisms to investigate, not assumptions that informal or external resources invariably substitute for formal rights.

Information is similarly consequential. A policy selected at time t can be based on observations and records available by that time, but it cannot, in ordinary circumstances, condition on the realised values of future disturbances. The notation π_a will designate such a *non-anticipative feedback policy*. A feasible intervention set $\mathcal{U}_a(x_t, \theta_t, r_t)$ may depend on the current state x_t , a representation θ_t of institutional or structural conditions, and the available resource stock r_t . The fact that a hypothetical intervention could change an outcome does not imply that the actor has access to it. The feasibility of the intervention, including permission to undertake it, belongs within the control problem itself.

Two task families help make the governance meaning more precise. *Regulatory control capacity* concerns keeping a selected condition within acceptable limits despite admissible disturbances: for example, preserving a minimum resource reserve or preventing an assigned workload from exceeding a sustainable bound. *Transformative control capacity* concerns reaching a different configuration, including a change in rules, responsibilities, or feasible forms of cooperation. The distinction is made by specifying different tasks and targets. It does not assume two independent psychological traits or imply that one type of capacity is normatively superior to the other. In practice, maintaining a protected sphere can make transformation possible, while institutional transformation can subsequently change what regulation costs.

The relational qualifier also matters. A focal actor’s policy is exercised among other actors whose choices can support, obstruct, reinterpret, or modify its effects. Depending on the empirical question,

these choices may be represented as strategic responses, negotiated joint actions, or disturbances bounded from the focal actor's standpoint. Treating the choices of other subjects as disturbances in a reduced model is a *perspectival modelling simplification*, not a claim that those subjects lack agency. A governance analysis may require a multi-actor model to investigate reciprocal influence or asymmetries in the power to change control rules.

2.3 Reachability, Viability, and Resource Constraints

The analytical role of control becomes clearer once feasibility is specified over time. Consider the discrete-time representation in Equation 2. It permits institutional conditions and available resources to evolve while keeping the number of formal objects small.

$$\begin{aligned} x_{t+1} &= F(x_t, u_t, d_t; \theta_t), \\ \theta_{t+1} &= G(\theta_t, x_t, u_t, d_t), \\ r_{t+1} &= r_t + i_t - c_t(x_t, u_t, d_t). \end{aligned} \tag{2}$$

The state x_t describes the aspect of a relation or organisation being studied; θ_t denotes its operative structural conditions; u_t is the focal actor's feasible intervention; and d_t represents influences not selected through that intervention. The functions F and G are unspecified evolution laws. The nonnegative quantity c_t is the resource cost of an intervention and response, i_t an inflow or replenishment, and r_t a resource stock. For simplicity, the resource equation represents one explicitly chosen, fungible resource. Time, money, trust, attention, and institutional standing are generally not interchangeable. An application involving several such resources would require a vector of stocks, resource-specific inflows and costs, and corresponding feasibility constraints; the scalar notation is retained only for this illustrative task. The function G allows, but does not presume, that intervention affects structural conditions; such effects can also depend on the responses of other actors.

Define the *augmented state* $z_t = (x_t, \theta_t, r_t)$, an admissible region $\mathcal{K}$ that contains the conditions to be maintained, and a target region $\mathcal{G}$ to be reached by a fixed horizon T . The task is specified further by an information-limited policy class Π_a , a family of admissible disturbance histories $\mathcal{D}$, and a resource budget $\bar{R}$. A robust version of task-relative feasibility is given in Equation 3.

$$\begin{aligned} \exists \pi_a \in \Pi_a \quad \forall d_{0:T-1} \in \mathcal{D} : \quad & u_t = \pi_{a,t}(h_t) \in \mathcal{U}_a(z_t), \\ & z_t \in \mathcal{K} \quad (0 \leq t \leq T), \\ & z_T \in \mathcal{G}, \\ & \sum_{t=0}^{T-1} c_t(x_t, u_t, d_t) \leq \bar{R}. \end{aligned} \tag{3}$$

In Equation 3, h_t contains the observations, past interventions, and other information legitimately available to actor a by time t . The quantified disturbances follow the admissible histories specified for the problem; the policy is selected before their future realisations are known. The resource reserve may additionally be protected by including a lower bound on r_t within $\mathcal{K}$. The budget $\bar{R}$ limits the cumulative intervention expenditure specified for the task, whereas the resource dynamics account separately for inflows and remaining reserves. Because these restrictions are distinct, satisfying a gross-cost budget alone does not guarantee that an actor can finance each intermediate intervention. If $\mathcal{G}$ is omitted, the question concerns *viability*, maintaining the path within $\mathcal{K}$ over the horizon. If the terminal target is retained, the question concerns constrained reachability. Related mathematical distinctions between reachability, stabilisation, and viability are established in the control and viability literatures [14, 2]. The particular conjunction of conditions in Equation 3 is an explicit analytical convention for this paper, not a newly established theorem.

It may be useful to represent the *minimum robust intervention expenditure* required for such a task. Let $\Pi_a^{\mathcal{K}, \mathcal{G}}$ be the class of information-admissible policies that satisfy the intervention, path, and terminal

conditions for all histories in $\mathcal{D}$. Equation 4 defines a conditional cost functional.

$$C_a^*(z_0; \mathcal{K}, \mathcal{G}, T, \mathcal{D}) = \inf_{\pi_a \in \Pi_a^{\mathcal{K}, \mathcal{G}}} \sup_{d \in \mathcal{D}} \sum_{t=0}^{T-1} c_t(x_t, u_t, d_t), \quad (4)$$

with $C_a^* = +\infty$ if that policy class is empty. Given the definition of the robustly feasible policy class, any budget strictly exceeding a finite infimum allows at least one such policy whose worst-case cumulative expenditure lies below that budget. Equality at an unattained infimum does not establish that a feasible policy meets the budget. This conclusion is conditional on the specified model and says nothing about feasibility under different disturbances, information, or resource accounting. The functional is explicitly task-relative, contingent on the modelled disturbance set, and dependent on how costs are defined. If the disturbances are probabilistic rather than treated robustly, a different risk criterion may be appropriate. Neither the scalar cost nor its inverse supplies a general-purpose index of an actor's power.

The three formulations clarify the temporal character of a governance claim. Regulatory and transformative tasks can have different targets, costs, and policy classes, while the feasible sets and institutional rules may change with θ_t . An actor might be able to keep a present arrangement viable yet lack a feasible pathway to a desired structural alteration. Another actor might possess an accessible pathway to a different role but insufficient resources to remain viable while traversing it. Cross-system support can influence resource replenishment, available interventions, or feasible targets, although those links would need explicit representation in an empirical model. A longer historical process can change F , G , the constraints, and the very variables considered relevant; the finite-dimensional model therefore captures only a selected window and representation of that process.

The use of the term *effective control capacity* in the remainder of the paper refers to these scoped capabilities. The modelling exercise neither identifies a critical point in an actual institution nor attributes stable attractors to particular organisations. It provides a grammar for asking whose interventions are feasible, which conditions can be sustained, which transitions are reachable, who bears the costs, and how a subsequent history may alter the answers. Section 3 uses this grammar to examine possible mechanisms of disturbance-related depletion and historical lock-in without assuming that either mechanism is inevitable.

3 Dissipation and Lock-In in Relational Systems

This section examines two mechanisms through which the relation between criticality and effective control capacity may acquire different consequences for an actor over time. The first concerns the resources needed to regulate disturbances when a system's own recovery mechanisms provide limited assistance. The second concerns the historical reinforcement of an established arrangement, which may make subsequent reconfiguration more difficult even while ordinary activities become easier to manage. A third step relates both mechanisms to the task-relative control definition of Section 2. The argument combines bounded dynamical examples with an interpretation of organisational routines and power relations. The examples identify conditional possibilities, not a universal trade-off, and the term *dissipation* refers here to expenditure or depletion of identifiable social and economic resources rather than to thermodynamic entropy.

3.1 Critical Disturbances and the Costs of Regulation

A system can respond strongly to disturbances without offering the actor concerned a correspondingly strong means of regulating their effects. In some dynamical models, weakening local restoring forces makes deviations more persistent and may amplify fluctuations. Near certain bifurcations, this change can be described as a loss of local stability or resilience, with the familiar qualification that different transition mechanisms have different indicators and responses [13, 15]. At the level of a workplace or institution, the relevant observation may instead be that changes in demand, authority, staffing, or

resource access repeatedly require compensatory activity. A similarity in language does not establish that the workplace is approaching a mathematical bifurcation. The empirical mechanisms and the actor's feasible interventions have to be specified separately.

An elementary controlled model makes the distinction between sensitivity and regulatory capacity explicit. Let e denote deviation from a chosen operating condition, $\kappa \geq 0$ a local restoring coefficient, $b > 0$ the effectiveness of intervention, u a signed control input, and w an unselected disturbance. Consider the conditional dynamics in Equation 5.

$$\dot{e} = -\kappa e + bu + w, \quad |u| \leq U, \quad |w| \leq D. \quad (5)$$

Suppose the task is to keep $|e| \leq L$, where $L > 0$ is an acceptable deviation bound. Under immediate state feedback, continuously available intervention, and the disturbance bound in Equation 5, a control input that acts inward at the boundary can keep the interval invariant when the capacity condition in Equation 6 holds.

$$\kappa L + bU \geq D. \quad (6)$$

At $e = L$, the most favourable admissible input is $u = -U$, yielding $\dot{e} \leq -\kappa L - bU + D$; the corresponding inward condition at $e = -L$ is symmetric. Thus Equation 6 is a boundary-invariance condition for this highly restricted scalar example. It does not account for delayed feedback, intervention rates, uncertain effectiveness, unobserved disturbances, or multidimensional feasibility. Those conditions can substantially alter the result.

Nevertheless, the example clarifies an aspect of the governance question. If the system's restoring contribution κL declines while the worst-case disturbance bound D and the acceptable deviation L remain fixed, the required intervention range may increase. Whether the actor can provide it depends on bU and on the availability of intervention when disturbances occur. The actor might possess a formal right to act yet face an insufficient feasible range U , low intervention effectiveness b , or institutional delays that make the idealised feedback unavailable. Formally granted discretion and effective disturbance regulation can therefore diverge.

Effective regulation also has a resource history. Equation 2 tracks a resource stock that changes with inflows and intervention expenditure. A state trajectory can remain inside an acceptable operating region for some time while the associated resource stock decreases. A repeated requirement to mediate disputes, repair interruptions, replace unavailable support, or absorb schedule changes might maintain the organisation's apparent continuity while using the actor's money, attention, working time, or professional relationships. These are analytically distinct resources; a case study should keep their units, replenishment processes, and substitutability explicit. For example, a person may receive sufficient financial compensation and still lack the time or institutional permission required to maintain external research relations.

The distinction is particularly important when regulation is distributed unequally. An organisation may have discretion to change assignment rules, staffing commitments, or performance demands, while a particular member has few effective means to modify them. The member then responds to disturbances generated or transmitted through a structure whose parameters they only partly influence. In the language of Section 2, the disturbance family, admissible intervention set, and information constraints are jointly shaped by relations of authority and cooperation. If adjustment burdens are allocated repeatedly to one party without corresponding resources or decision rights, aggregate operational continuity can coexist with concentrated depletion. That is a candidate mechanism of unequal cost allocation, not an empirical accusation against any particular organisation.

The consequences of disturbance are not universally adverse. Some variations provide information, reveal deficiencies in existing arrangements, or create opportunities for cooperation. Moreover, interventions may lower future exposure by changing processes rather than repeatedly correcting immediate deviations. A stable routine, external assistance, or institutional safeguard can make recovery inexpensive. The claim needed for this inquiry is consequently limited: *when disturbance exposure and the costs of response exceed the actor's feasible capacity for regulation and renewal, a locally open or sensitive*

arrangement may become resource-depleting. The analytical task is to identify the conditions and their distribution, not to classify all critical or variable systems as undesirable.

3.2 Stabilisation, Attractors, and Historical Lock-In

Stabilisation has a different temporal structure. A reliable practice can reduce uncertainty, economise attention, preserve knowledge, and support cooperation over time. In organisational settings, repeated performance may consolidate routines, recognised competences, channels of authority, and expectations about future conduct. Evolutionary accounts of organisational behaviour assign an important role to such routines and their selection [10]. Their persistence can be productive: without some continuity in rules and relationships, ongoing coordination and cumulative learning would be difficult. The presence of a stable arrangement therefore provides no sufficient basis for a diagnosis of lock-in.

A possibility of lock-in arises when the mechanisms supporting an established arrangement also raise the cost of developing alternatives. Skills and equipment may become specialised to existing tasks; partners may make complementary investments; evaluation criteria may reward a narrow form of performance; and the actor's accumulated obligations may make an alternative relationship expensive to enter. These mechanisms need not involve explicit prohibition. Incentives, expectations, sunk expenditures, and repeated selection can jointly make the current path comparatively easier to continue. Established work on increasing returns and path dependence explains why historical timing, early contingencies, and self-reinforcing institutional processes may influence later feasible choices [1, 12].

An attractor provides one possible dynamical analogy for the resulting persistence. Repeated adjustment within a regime can return activity toward familiar routines, and the basin of attraction can represent the states from which those dynamics reproduce the regime. The analogy is most informative when a state representation and transition mechanism can actually be specified. Institutional persistence alone does not demonstrate the existence of a mathematically invariant attractor, and a costly contractual exit is not necessarily a bifurcation. The terms *path dependence*, *lock-in*, *hysteresis*, and *attraction* have overlapping applications but different criteria: historical effects need not imply multiple stable states, while multistability in a mathematical model does not by itself identify the economic or political mechanism producing an institution.

For a focal actor, the important separation is between the capacity to operate efficiently within an arrangement and the capacity to alter the conditions under which that arrangement is maintained. The former can improve through familiarity and delegated discretion while the latter stagnates or declines. An experienced coordinator may be able to settle day-to-day problems with little effort yet have no realistic authority to alter staffing levels, compensation rules, or the distribution of final decisions. Conversely, a formal manager may possess substantial authority over current procedures while remaining bound by external regulation, budget commitments, or partner dependencies. Regulatory control and transformative control in Section 2 capture these different tasks without presuming that a particular job title entails either capability.

The exploration–exploitation distinction in organisational learning is useful here because the development of reliable existing practices can have a different time profile from the development of alternatives. March's analysis describes the allocation of learning resources between exploiting familiar competencies and exploring new possibilities, including the uneven distribution of costs and benefits over time [9]. The present paper draws on that established distinction for a narrower interpretive question: when does improved operation inside a relationship coincide with the deterioration of an actor's feasible routes to a different relationship? The answer depends on the transferability of skills, actual access to alternative partners, contractual restrictions, resource reserves, and the ways other actors respond to attempted change.

It is also possible for greater stability to expand future opportunities. Durable income, predictable time, reliable legal rights, and trusted cooperation may allow an actor to cultivate abilities and external relationships that would otherwise remain inaccessible. An apparent attractor in one domain can provide a platform for exploration in another. Likewise, a previously restrictive institution can change its own

rules and make reconfiguration easier. A historical analysis must therefore examine the *mechanism of stabilisation* and the *location of emerging constraints*, rather than infer a uniformly shrinking landscape from stability alone.

3.3 Control Capacities and Changing Transition Costs

The preceding mechanisms can be brought together through a task-relative comparison. A regulatory task asks what interventions keep an operating condition viable despite disturbances. A transformative task asks what interventions make a different organisational or relational condition reachable while respecting resource and institutional constraints. In the framework of Equation 4, each task can have its own goal set, feasible controls, disturbance assumptions, and time horizon. Consequently, a change in the costs of one task gives no general answer about the other. In particular, a decrease in the expenditure needed for normal operation can coincide with an increase in the expenditure needed for structural change.

A linear control example isolates one route through which this divergence is possible, without requiring the stronger claim that all social lock-in behaves as a dynamical attractor. Consider $\dot{q} = -kq + bu$, with $k > 0$ and $b > 0$, and start at $q(0) = 0$. Treat $q(T) = L > 0$ as a stipulated alternative state at a fixed horizon $T > 0$, and measure intervention by $J = \int_0^T u(s)^2 ds$. If the input is unconstrained, uncertainty is absent, and the only requirement is to attain the terminal state (without path constraints), standard minimum-energy reasoning gives Equation 7.

$$J_{\min}(k, b, L, T) = \frac{2kL^2}{b^2(1 - e^{-2kT})}. \quad (7)$$

Indeed, the terminal condition is $L = b \int_0^T e^{-k(T-s)} u(s) ds$; the Cauchy–Schwarz inequality bounds the cost from below, and the bound is attained by an input proportional to $e^{-k(T-s)}$. For fixed b , L , and T , the minimum cost in Equation 7 grows with k . As k tends to zero from above, it approaches $L^2/(b^2T)$. Stronger reversion toward the starting state is therefore associated with a higher cost of reaching the stipulated alternative within the same time horizon in this particular model. Meanwhile, the same reversion term can assist regulation against small deviations. This juxtaposition is an illustration of task dependence, not evidence that larger organisational stability must cause historical lock-in.

Several limits matter. The quadratic cost is an illustrative control-effort functional, not a validated index of financial, organisational, or psychological expenditure. The example has a fixed target, fixed structure, complete input access, and no admissibility constraints on intermediate states; it consequently omits precisely the institutional negotiations, competing agents, and evolving opportunities of most governance problems. Moreover, reaching $q = L$ is not equivalent to reaching a critical point. The alternative state serves only as a transparent proxy for a specified change in the controlled state. Translating the example into claims about a particular social relationship would require explicit variables, observable constraints, and empirical support.

In an evolving relational system, both regulatory and transformative costs may themselves be endogenous. Training can improve intervention effectiveness. Legal protection can make refusal or exit feasible. Repeated obligations can reduce available time. Institutional learning may lower the cost of revising rules. A change in partners or technology may create destinations that were previously inaccessible. Conversely, a nominally available exit route can become practically infeasible if the actor lacks the resources needed to survive a transition. These are different changes to the feasible set, cost structure, target space, or disturbance exposure. The general construct C_a^* in Equation 4 permits conditional comparison when a model is specified, but it does not assign a model-independent rank to historical paths.

The distribution of authority affects these changes. One party may select a new target, alter organisational rules, or determine when a transition must occur; another may only supply the labour required to implement the decision. The costs of transition and the gains from it can therefore accrue to different actors. Even an intervention that increases an organisation’s flexibility need not expand the feasible pathways of each participant. Conversely, a member’s departure may improve that member’s future options

while placing adjustment costs on colleagues. An analysis of generative possibilities must keep the actor, the target, the relevant time horizon, and the distribution of costs explicit.

The two mechanisms investigated in this section consequently do not establish a binary choice between criticality and controllability. Disturbance-related depletion and historical lock-in are contingent pathways that can coexist, counteract one another, or be mitigated by relations outside the immediate setting. They are also subject to change: institutions acquire routines, actors build or lose reserves, permissions are revised, and new collaborators may appear. These observations prepare the evolutionary argument of Section 4: the conditions under which control is effective, stability is maintained, and transitions are reachable are themselves historically produced and potentially revisable. The inquiry remains descriptive and conditional, leaving comparative welfare and normative governance judgments to their own explicit criteria.

4 The Historical Coevolution of Control and Criticality

The costs of regulation and reconfiguration identified in Section 3 depend on arrangements that may themselves change. This section examines the historical production of those arrangements, with particular attention to organisational routines, effective control capacity, critical conditions, and feedback across successive decisions. The method is an interpretive synthesis of established evolutionary-economic mechanisms and the task-relative control framework of Section 2. The analysis seeks to specify possible processes and discriminating questions; it does not establish a universal order in which control or criticality must develop. Four steps organise the discussion: the reproduction and selection of routines, changes in the capacities available to actors, changes in the conditions for qualitative transitions, and feedback that links these developments across time.

4.1 Routines, Learning, and Selection

Economic and organisational evolution may proceed through the repeated performance, adaptation, and replacement of practices. Routines coordinate work, convey expectations, and retain experience beyond any one occasion of their use. Their relative persistence can lower the cost of ordinary cooperation while also making certain alternatives less familiar or less institutionally legible. Nelson and Winter's evolutionary treatment of organisational routines, search, and selection provides a major foundation for analysing these processes without assuming that actors continuously optimise over a complete and stable menu of alternatives [10]. Dosi's account of technological paradigms and trajectories likewise highlights how inherited problems, skills, and directions of search shape subsequent development [4].

Variation, selection, and retention are analytically distinguishable, although in organisational practice they are intertwined. A member may propose a different reporting practice, a team may adapt it, and an authority may decide whether the alteration is recognised as part of normal work. The new practice can then alter what counts as competent performance and which further changes appear legitimate. Some variations remain informal; others become documented procedures, budget commitments, or rights that survive the individuals who initiated them. The relevant unit of persistence therefore need not be an unchanging organisation. It can be a rule, technique, expectation, or coordination arrangement carried by a changing population of participants.

The micro-meso-macro approach of Dopfer, Foster, and Potts situates rules and their actualisation within an explicitly evolutionary architecture [3]. That perspective is useful here as a comparison rather than a foundation to be appropriated or renamed. An individual's learning, the uptake of a shared rule, and the wider distribution of that rule across institutions involve distinct processes. A gain in competence for one worker does not by itself imply a change in an organisation's rule structure, while the diffusion of a rule across organisations need not improve each participant's circumstances. A relational inquiry must trace the relevant carriers, authorisations, and pathways through which local variation either remains local or becomes consequential elsewhere.

Selection is also conditioned by authority and resources. An actor with permission to allocate staff time, approve experimental practices, or set evaluation criteria can influence which variations receive an opportunity to persist. Other actors may supply knowledge or labour while holding little influence over selection. Yet selection is rarely under unilateral control: clients, colleagues, regulators, funders, market conditions, and organisational histories can constrain what a formal decision-maker can retain. The observed survival of a routine may result from efficiency, coercive exclusion of alternatives, a coordination advantage, institutional inertia, or several mechanisms together. Its survival alone provides no valid measure of its social value or its contribution to any particular actor's future possibilities.

Learning can also redistribute the balance between improving a familiar practice and searching for alternatives. March's exploration–exploitation analysis describes how adaptation to existing competencies and experimentation with unfamiliar possibilities can produce different temporal patterns of learning and returns [9]. A practice that facilitates present coordination may leave resources for future experiments, but it may also absorb training, attention, and rewards that might otherwise support exploration. The result depends on replenishment, institutional discretion, and the relevance of accumulated capacities beyond the current practice. These mechanisms provide a historical route by which the effectiveness of present regulation and the feasibility of later reconfiguration can change together, without requiring either change to precede the other in general.

4.2 The Endogenous Evolution of Control Capacities

Effective control capacity was defined in Section 2 relative to a particular actor, feasible interventions, observations, resources, disturbances, and a task. Its historical evolution can therefore be investigated by examining changes in those components. Training can improve the execution of an available intervention; reliable information can make a policy responsive to emerging disturbances; a contract can confer or restrict permission; financial reserves can extend the horizon over which an alternative remains viable. The same worker, performing the same nominal role, may consequently acquire greater or lesser control capacity even when the formal organisational chart remains unchanged.

A useful distinction concerns the *availability* of intervention and its *effectiveness*. A new rule may authorise an actor to request assistance without ensuring that such assistance is actually supplied. A formally discretionary budget may be difficult to use because of approval delays. Conversely, a trusted collaboration may improve the practical effect of an action without granting any formal managerial title. In the controlled-system representation of Equation 2, these changes may be represented, where appropriate, through the feasible intervention set, the effectiveness of interventions within the evolution law, the information accessible to a policy, or the replenishment of resources. The components should remain separate when they generate different observable implications.

This distinction also explains how regulatory and transformative capacities may diverge over time. Repetition can make ordinary disturbances easier to address, increasing the reliability of established operations. Simultaneously, incentives for specialised performance may narrow transferable skills or weaken external partnerships. In another setting, experience with present operations can build credibility, savings, and relationships that make structural revision or exit easier. An increase in regulatory effectiveness is thus compatible with either an increase or a decrease in transformative feasibility. The comparison is meaningful only after identifying each task, the actor affected, and the horizon over which change is assessed.

Research on dynamic capabilities offers an existing vocabulary for organisational processes through which competencies, assets, and inherited paths condition adaptation to change [16]. Its usual concern with enterprise strategy and competitive performance, however, should be distinguished from the present paper's question about situated actors in heterogeneous institutional relationships. A capability that permits an organisation to reconfigure its assets might leave an individual employee with reduced bargaining power, while an individual's expanded capacity to leave might impose replacement costs on the organisation. Organisational adaptation, individual control, and collectively desirable governance outcomes require separate descriptions.

Control capacity can also change through its own exercise. An intervention may produce records, skills, trust, obligations, and expectations that influence later interventions. A successful local adjustment may justify broader delegation, or it may invite additional work without corresponding authority. A collective challenge to a rule may generate a new appeal procedure, while an unsuccessful challenge may lead to more restrictive permission. The future feasible intervention set is partly an outcome of interactions in which existing capacities have already been used. This is a more precise claim than treating power as a fixed endowment: the relevant causal sequence runs through specified permissions, capacities, organisational responses, and resource changes.

For analytical purposes, the question is therefore not simply whether the actor possesses more control at a later date. One must ask whether the newly feasible interventions address the same goal, whether disturbance exposure has changed, and who can revise the criteria by which success is judged. An actor might gain operational discretion while losing the practical ability to refuse an expanded workload. Another might acquire independent resources while relinquishing internal decision-making authority. Neither trajectory can be ranked by a context-free scalar called *control*. The task-relative framework permits comparison within a specified model while preserving differences in what the control is for.

4.3 Changing Critical Conditions and Feasible Transitions

In the strict dynamical usage adopted in Section 2, a critical transition is a property of a specified evolution law and its conditions, rather than a synonym for novelty, instability, or desirable change. Institutions can alter their response to perturbations as rules, resources, technologies, and interdependencies evolve. A change in the underlying parameters can modify local recovery rates, the existence or stability of equilibria, and the possible trajectories under an identified model. Empirical work would be needed to establish whether any such mathematical feature is present in a particular organisation. Historical changes in observed experimentation or turnover, by themselves, warrant a narrower institutional interpretation.

An organisation's apparent sensitivity to a disturbance can change for several reasons that need not involve a bifurcation. A new procedure may channel complaints into an ordinary review process; a previously informal collaboration may become supported by a stable budget; a change in staffing can leave less capacity to absorb unexpected demands. Each development may alter the consequences of an input, yet the transformation could remain continuous and far from any critical threshold. Conversely, a model with a true loss of local stability would require state variables and observations capable of discriminating a structural shift from ordinary variation. The language of criticality should thus be reserved for its technical use or explicitly marked as a conjectural analogy.

The landscape metaphor in prior organisational research also has an established technical lineage. Levinthal's account of adaptation on rugged landscapes links interactive organisational attributes, local adaptation, and environmental selection, including cases in which founding configurations influence subsequent trajectories [8]. It provides a relevant antecedent for considering historically situated feasible moves. At the same time, a fitness landscape in a particular model is not equivalent to a task-relative reachability set, a welfare ordering, or an ontological description of all social possibilities. Different formalisms answer different questions. The present discussion makes no claim to introduce landscape reasoning or its historical endogeneity.

Consider, as an illustrative sequence, a collaborative unit that initially requires central approval for nearly every adjustment. Its staff accumulate shared records and demonstrate that a bounded class of changes can be managed safely. The institution may respond by delegating decisions, making local interventions less costly and reducing delays. It might then introduce a new information system that enables coordination with previously unavailable partners. The same historical process has changed ordinary control effectiveness, institutional permission, and the set of feasible collaborations. Whether the unit has thereby moved closer to or farther from a critical regime cannot be inferred without a separate dynamical specification. More plausibly, the admissible problems, paths, and relationships have themselves changed.

The reverse sequence is also possible. A temporary funding rule may make experimentation easy while exposing members to recurring income risk. If the arrangement persists, accumulated commitments and depleted reserves can narrow feasible alternatives despite continued nominal freedom to experiment. Later, an external grant, an employment contract, or a mutual-support agreement might restore some options without altering the original organisation's rules. This is a hypothetical account of changing constraints, not an empirical claim about funding systems or employment. It shows why accessibility depends on an actor's relations beyond the focal institution and why a present inventory of internal permissions may be insufficient for long-horizon analysis.

In this sense, the *conditions of transformation* have a history. The set of admissible actions, the risks of transition, the target states worth considering, and the time needed to construct a new relationship may all change. A desire to "return" to a previously open regime may be ill-defined when the prior regime's enabling institutions, partners, or skills no longer exist. The relevant future may involve a distinct opportunity made possible by subsequent learning and coordination. This observation motivates the paper's later examination of generative landscapes, while leaving their definition and comparison to Section 5.

4.4 Relational Feedback and Historical Contingency

Coevolution requires more than the observation that several variables move over time. The explanatory task is to identify how a change in one relational condition alters the process through which another condition subsequently changes, and how the resulting responses may feed back into the former. The proposed units of analysis include actors, permission structures, routines, resource stocks, and feasible tasks. Their relations may form reinforcing loops, balancing loops, delayed responses, or mutually constraining processes. The direction and magnitude of any such link remain questions for historical and empirical inquiry.

A reinforcing sequence might begin when reliable performance earns an employee greater discretion. Discretion permits local experimentation, which produces a useful coordination practice; the organisation then incorporates the practice and delegates comparable decisions more widely. A different sequence could begin with increased discretion that brings unbounded responsibility, diverts time from external learning, and reduces feasible exit options. In both cases, the eventual condition of control depends on choices and responses distributed across the organisation. Initial control is neither an unambiguous cause of later openness nor an inherently stabilising force. The intermediate arrangements make the difference.

Feedback can also be indirect. A worker's external cooperation may supply knowledge that improves an internal practice. The improvement can generate organisational support for continued cooperation, or it can result in additional internal obligations that displace it. The distinction involves more than the quantity of relationships: contractual boundaries, time commitments, recognition of contributions, and the relative authority of participants shape whether connections complement or crowd out one another. Section 5 examines such cross-system relations more closely; at this point, their importance is to show that the evolution of any focal relationship is partly conditioned by interactions outside its immediate boundary.

Several historical qualifications prevent a deterministic reading. First, the same intervention may yield different outcomes when resources, institutional rules, or other participants differ. Second, relevant actors can learn and change their aims, so an earlier target need not remain the appropriate target later. Third, selection can preserve routines through advantage, convention, coercion, or simple lack of feasible competitors; persistence alone does not identify its cause. Fourth, external shocks can interrupt feedback sequences before the expected result occurs. Finally, the resources and risks of a transition may be allocated asymmetrically, allowing one participant's capacity to grow while another's deteriorates.

These qualifications matter for governance analysis because an evolving relationship cannot be evaluated by a single static measure of order or openness. One can instead reconstruct concrete sequences: which practices were available, who authorised them, what resources supported them, which effects altered subsequent choices, and whose feasible tasks expanded or contracted. Process tracing and com-

parative institutional inquiry may help distinguish reinforcement from alternative mechanisms. Formal simulation could clarify conditional consequences once the relevant variables and updating rules are specified, but an illustrative simulation would not in itself identify actual historical causes.

The analytical outcome of this section is the need to follow identifiable feedback across historical episodes. Established evolutionary-economic approaches investigate routines, selection, adaptive capacities, and trajectories. Their interaction with task-relative effective control capacity and carefully specified critical conditions provides a basis for comparing such episodes. Control effectiveness, institutional stability, and the conditions of qualitative change can influence one another over time, while their effects vary across actors and tasks. The next step is to examine how participation in multiple relational systems may alter this evolution and, with it, the future opportunities available to situated actors.

5 Relational Complementarity and Generative Landscapes

The analysis of control and criticality changes when an actor participates in more than one relational system. Resources accumulated in a comparatively stable relationship may support experiments undertaken elsewhere; a developing collaboration may, in turn, alter the actor's capacities and obligations in the original setting. This section examines such complementarity without treating participation in several systems as necessarily beneficial. It first specifies how multiple memberships condition effective control capacity, then considers enabling and constraining relations among resources and capabilities. On that basis, it introduces *generative landscape* as a provisional description of historically changing feasible relations and transitions. The final subsection addresses the unequal distribution of access, costs, and benefits. The discussion is conceptual and uses stylised scenarios, without attributing empirical properties to identifiable organisations.

5.1 Actors Across Multiple Relational Systems

An individual or collective actor can hold several positions at once: an employee in an organisation, a participant in a research community, a member of a household, a contributor to a voluntary association, and a party to market or public-institutional arrangements. Each position entails distinct expectations, resources, permissions, dependencies, and forms of recognition. The relevant configuration is consequently more extensive than the formal boundary of any one organisation. For a task such as maintaining an adequate livelihood while retaining an opportunity to study, the admissible interventions depend partly on the actor's relations beyond the workplace. For a task such as revising an internal routine, knowledge or support acquired externally may change the feasibility of the proposed revision.

It is useful to distinguish *membership*, *access*, and *effective mobilisation*. Membership identifies a recognised role within a relationship; access concerns resources, knowledge, or decision channels that the relationship makes available; effective mobilisation concerns the actor's ability to deploy those opportunities for a specified task under existing conditions. A professional contact may provide information without offering time, institutional authority, or a reliable route to collaboration. An external affiliation may confer reputational benefits while imposing obligations that restrict other work. Conversely, a modest social relationship may provide practical support when formal organisational channels are unavailable. The difference matters for Definition 2.1: the feasible intervention set is sensitive to what can actually be mobilised, not simply to the number of organisations with which an actor is associated.

Relations across systems are also mediated. An employer may permit, restrict, or condition activities undertaken outside working hours; household responsibilities may alter the amount of time available for training; legal and professional obligations may prevent information acquired in one position from being used in another. Knowledge and resources therefore have degrees of portability. Some skills are readily transferable, whereas others depend on particular equipment, trusted collaborators, tacit practices, or recognised credentials. The account of combinative capabilities developed by Kogut and Zander connects learning and future possibilities to accumulated knowledge and established relationships within firms [7]. This established argument offers a useful precedent for investigating the conditions under

which capabilities might, or might not, be carried across institutional boundaries. Such transfer cannot be presumed in a setting involving confidentiality, professional responsibility, or restricted data.

A multi-system description further requires temporal specificity. Two relationships may be formally compatible yet compete for the same hours, attention, or reserves. A collaboration that is useful at one stage may become difficult to maintain after an employment schedule changes. External relations may also be jointly exposed to economic downturns or organisational policy changes. Counting them as independent sources of security would conceal these correlations. Relevant evidence would include the actor's actual schedule, contract conditions, transferable skills, dependable reciprocal commitments, and the resources required to keep each relationship active.

Polycentric governance scholarship provides a related but distinct analytical point of reference. Ostrom's analysis of multiple centres of decision-making discusses experimentation, learning, and collective action across scales in the context of global environmental governance [11]. The present problem concerns an actor's participation across several relationships, which is not equivalent to a polycentric public-governance arrangement. Nevertheless, that literature cautions against assuming that all effective coordination must be organised by a single decision centre. Whether decentralised or overlapping relations are advantageous remains a question about their specific institutions, tasks, and costs.

5.2 Resource Complementarity and Evolving Capabilities

Consider two possible, deliberately hypothetical sequences. In the first, an actor accepts work that provides predictable income, limited discretionary authority, and relatively stable responsibilities. An independent research association or professional network then supplies opportunities for exploration that the employment arrangement does not provide. In the second, an actor initially joins a less secure but professionally open collaborative setting and later develops another income source or institutional affiliation that permits continued participation. Neither sequence is necessarily superior. Their viability depends on the timing of resource inflows and obligations, the authority to undertake parallel activities, the quality of the relationships, and the costs of maintaining them.

The first sequence may contain a reinforcing mechanism. Predictable income covers essential expenditure and permits reserves to accumulate. Reserves may reduce the cost of declining an unsuitable assignment, make temporary retraining feasible, or support travel and communication necessary for an external collaboration. Successful collaboration may then extend the actor's skills and outside options. A larger set of credible alternatives can change bargaining conditions within the initial employment relationship even if the actor's formal rank remains unchanged. This sequence illustrates a possible expansion of effective control capacity through cross-system conditions; the causal links must be investigated separately in any real case.

The same initial employment can generate a different trajectory. Unpredictable overtime, restrictions on outside activities, and progressively narrower specialisation may leave little capacity for external work. The actor can become highly competent at current routines while losing the time and resources needed to maintain other pathways. In that case, apparent security coexists with increasing transition costs. The relevant governance question is therefore not whether the workplace is stable, but whether stability yields resources that remain accessible for other tasks and whether the costs of reproducing that stability crowd out those tasks.

In the second sequence, participation in an open collaboration may provide early access to international contacts, unfamiliar practices, and new professional knowledge. These relations can make later opportunities available that were previously unknown or infeasible. Yet uncertain compensation and repeated coordination work can deplete reserves before a second resource channel is established. A prospective side activity may require more administrative effort than expected or conflict with contractual, legal, or ethical duties. A possible supplement to income is not equivalent to an available supplement at the time when it is needed. The distinction between anticipated and realised complementarity is especially important when financial survival is at stake.

Resource complementarity thus has several distinguishable meanings. *Buffering* occurs when one

relationship supplies resources that absorb disturbances experienced in another. *Capability combination* occurs when knowledge or practices acquired in different settings jointly enable a task that neither would support alone. *Option preservation* occurs when an available external relationship keeps a future transition practicable. *Mutual crowding-out* occurs when obligations or restrictions in one relationship diminish the feasibility of activities in another. These are descriptive categories rather than a comprehensive taxonomy or a novel theoretical classification. March’s established distinction between exploration and exploitation is useful here, particularly because the costs and benefits of organisational learning are distributed across time [9]. Complementarity is not the numerical addition of more exploration to more stability: the mechanisms connecting them determine what the actor can sustain.

Resource stocks and capabilities also evolve at different rates. Income may change monthly, a credential may require years, trust may depend on repeated interactions, and a professional permission may be withdrawn immediately. Some resources have substitute uses; others are non-fungible. An actor cannot always replace a trusted collaborator with money, or compensate for a legal restriction by investing more time. The scalar resource variable r_t in Equation 2 represents only one selected resource. Modelling heterogeneous resources would require the vector-valued extension described in Section 2, with separate limits on non-fungible stocks. The minimum-cost construct in Equation 4 can be applied to a specified task once the resource and admissibility constraints have been identified. It cannot infer complementarity solely from the presence of multiple affiliations.

Cross-system complementarity can also develop endogenously. A small external collaboration may improve a method used at work; recognition of that improvement may lead to additional discretion; greater discretion may then make future collaboration easier. Alternatively, recognition may bring additional obligations, reducing the actor’s time outside the organisation. In either sequence, one relationship changes the conditions of another. The outcome depends on actual institutional responses, and may include a loss rather than a gain in the capacity for future reconfiguration. The historical significance of a relationship consequently extends beyond its immediate outputs to the pathways it helps sustain, revise, or close.

5.3 The Historical Transformation of Generative Landscapes

The expression *generative landscape* is used here as a provisional analytical description of an actor’s historically conditioned possibilities for activity, association, and structural change. It refers to feasible states and relations, transitions that can be attempted, the resources and permissions governing their feasibility, and the distribution of associated benefits and costs. The term is not intended to identify a natural kind, a uniform measure of creativity, or a complete catalogue of future events. In particular, it does not presume that the actor can enumerate all possible relationships or assign each an unambiguous value.

For orientation, one may represent an actor-relative landscape at time t , conditional on a relevant history h_t , as

$$\mathcal{L}_a(t \mid h_t) = (\mathcal{X}_t, \mathcal{E}_t, \mathcal{U}_{a,t}, \mathcal{R}_{a,t}, \mathcal{Q}_t). \quad (8)$$

Here $\mathcal{X}_t$ is a chosen representation of relational states or configurations, $\mathcal{E}_t$ denotes the feasible-transition structure under the assumed institutional setting, $\mathcal{U}_{a,t}$ identifies interventions available to actor a , $\mathcal{R}_{a,t}$ records relevant resource and maintenance constraints, and $\mathcal{Q}_t$ represents the allocation of decision rights, obligations, access, and costs among participants. The history h_t indexes earlier events and arrangements that help constitute the present configuration. These entries are analytical placeholders that require task-specific definitions. Their separation is useful because an actor’s accessible options can change even where the list of nominally possible states has not, and institutional rules can change without an immediate observed transition.

Equation 8 should not be interpreted as a universal state-space ontology. In empirical work, the representation will omit unanticipated events, poorly recorded relationships, and forms of agency that the analyst has not recognised. Some future possibilities cannot be specified before the requisite capacities, institutions, or interpretive categories emerge. A historical reconstruction can establish which

arrangements became feasible and how particular enabling conditions were formed, but it cannot ordinarily provide an exhaustive inventory of unrealised futures. Moreover, the representation is actor-relative: a new contractual option for one participant may remain inaccessible to another even within the same organisation.

Landscape language has substantial prior uses. The NK framework of Kauffman and Weinberger models rugged fitness landscapes for combinatorial adaptive processes, while Levinthal applies rugged-landscape reasoning to organisational adaptation and historical starting conditions [5, 8]. These established models involve specific assumptions about interacting components, evaluation functions, and adaptive search. The expression in Equation 8 is an analytical convention for this discussion and does not derive a single fitness function from relational reality. If a measurable performance criterion and set of admissible transitions can be specified, a fitness-landscape model may be useful as a special-purpose representation. Where multiple participants evaluate outcomes differently, an imposed common height function could obscure distributive conflict rather than clarify it.

Three kinds of historical change are particularly relevant to this conceptual use. First, *changes in accessibility* occur when an actor gains or loses resources, permissions, information, or partners required for transitions already identifiable within a model. Second, *changes in transition structure* occur when a new rule, technology, or cooperation practice alters the connections among represented states. Third, *changes in represented possibilities* occur when previously unrecognised or practically unavailable kinds of activities become meaningful objects of action. These distinctions are provisional tools for describing examples. A single development may involve several kinds at once, and an empirical inquiry would need to trace the mechanism rather than infer it from the later outcome.

For example, an external training relationship may initially increase only the actor's proficiency in a familiar task. It may later permit access to a professional community, whose members develop a new collaborative practice. The emerging practice can change institutional expectations, making a kind of joint project feasible that was not part of the actor's original options. The sequence illustrates a possible alteration in what may be attempted, in who can attempt it, and in the conditions for subsequent learning. A contrary sequence is equally possible: a formerly open collaboration may cease, a credential may become obsolete, or a restrictive policy may render a previously feasible route inaccessible. The landscape metaphor encompasses the loss and closure of possibilities as well as their creation.

A change in the landscape need not coincide with a mathematically defined bifurcation or critical transition. Section 2 introduced criticality under specific dynamical assumptions; the broader description in Equation 8 concerns historically feasible relations and changes in their conditions. The two can be linked in a particular empirical model, but their analytical domains remain distinct. Similarly, a landscape's enlargement is not by itself a welfare improvement: some new pathways involve coercion, harmful dependencies, or increased demands on others. The landscape description offers an object of inquiry, not a normative ranking of histories.

5.4 Uneven Opportunities and Distributed Costs

The consequences of relational complementarity are distributed among actors who hold different rights and bear different obligations. An employer may acquire a valuable procedure through an employee's external learning, while the employee bears the expenses of that learning. A community organisation may gain continuity from the unpaid efforts of volunteers, while those volunteers face growing opportunity costs. A joint project may increase the reputation or future bargaining power of one partner while imposing maintenance responsibilities on another. These are hypothetical mechanisms that require evidence in particular settings; they illustrate why system-level capacity and actor-level capacity should be evaluated separately.

Formal authority can influence both the available pathways and the allocation of their costs. One participant may have the right to approve outside activities, allocate credit, define a successful project, or terminate access to shared infrastructure. Another may provide the expertise or labour needed to make the project possible without gaining comparable authority over its continuation. Governance analysis

should therefore attend to who can initiate a transition, who can block it, whose consent is required, whose resources are consumed, and who retains the capacities created by the collaboration. The distribution of *control over changing conditions* may matter as much as control over the current allocation of tasks.

The relevant distinctions extend to temporal horizons. A rule that reduces coordination costs this year may concentrate dependence on a single intermediary over several years. A difficult transition may impose substantial short-term demands but build more reliable rights and resources later. The effects cannot be ranked without specifying an actor, a time horizon, an evaluative criterion, and plausible alternatives. Persistence of a relationship does not establish that all participants regard it as beneficial, and increased productivity does not establish an equitable division of effort or recognition.

Multiple relationships can redistribute risks rather than eliminate them. A supplementary job may stabilise an individual's income while transferring unpaid coordination work to a household member. An institution may welcome an employee's external professional contacts while expecting additional work without corresponding discretion. Two cooperating organisations may appear mutually reinforcing until a shared funder, technical dependency, or legal restriction affects both simultaneously. The possibility of correlated disturbances, delayed costs, and concealed third-party burdens places limits on treating diversification as a general solution to vulnerability.

For these reasons, evaluating a historical landscape requires at least three separable descriptions: the feasible paths available to specified actors, the processes through which those paths are maintained or revised, and the distribution of resources, exposure, and authority associated with them. The first is related to reachability, the second to relational and evolutionary mechanisms, and the third to political-economic and normative questions. None can stand in for the others. A social arrangement may preserve a desirable option for one actor while making another's basic security less viable. Determining whether that arrangement is justified requires additional ethical and institutional criteria beyond the mere existence of options.

This section therefore leaves the inquiry with a more specific account of the historical governance problem. An actor's effective control capacity can be supported or diminished through relations beyond the focal organisation. Interactions among these relations may alter resources, permissions, and the feasible structure of future action. The proposed landscape vocabulary collects those changing conditions for study while preserving distinctions among actor-relative access, dynamical criticality, and normative value. Section 6 returns to the initial dilemma through these distinctions, considering what governance might reasonably attend to without deriving a general preference for either criticality or controllability.

6 Governance Implications and Concluding Reflections

The relation between criticality and control becomes a governance problem when actors face disturbances, changing institutional permissions, and uncertain prospects for revising the conditions under which they act. The preceding analysis distinguished the capacity to sustain a specified arrangement from the capacity to reach another arrangement; it also considered how participation across several relationships can alter both tasks. This final section draws limited implications from those distinctions, identifies the claims that remain theoretical or conjectural, and returns to the initial question without assigning universal precedence to criticality or controllability. The discussion concerns possible mechanisms and questions for inquiry. It supplies neither an empirically tested governance programme nor an assertion of conceptual novelty.

6.1 Governance in Evolving Relational Conditions

Governance arrangements help determine which interventions are permitted, whose information is considered, how resources are allocated, and what happens when expected routines fail. These arrangements also affect the conditions under which future revisions can be undertaken. A rule that assigns responsibility for unforeseen work may preserve immediate operational continuity while gradually altering time available for learning, relations of dependence, and the credibility of refusing additional obligations. A

rule that creates an appeal channel may have a modest immediate effect on output yet change the kinds of adjustment participants can later request. Such possibilities make the history of governance relevant to the present feasibility of action. The analytical aim is to identify mechanisms by which a particular rule or practice changes an actor's feasible tasks and the distribution of their costs.

Definition 2.1 offers a useful starting point because the ability being evaluated must be specified relative to a task. The capacity to absorb a short-term workload increase may be assessed against a reserve requirement, an admissible disturbance range, and an agreed time horizon. The capacity to change a reporting requirement, in contrast, depends on access to decision channels, the institution's amendment procedure, other participants' responses, and the resources available for sustained negotiation. Treating these capacities separately makes it possible to examine an arrangement that is effective at routine coordination yet difficult to revise. It also leaves room for an arrangement that offers few formal management powers but supports credible proposals, negotiated adjustments, and independent learning.

A further implication concerns the meaning of *control* in collective settings. The action set $\mathcal{U}_a$ in Equation 3 is actor-relative, whereas many governance outcomes require cooperation or consent among several actors. An individual may be able to request a change, but lack permission to implement it unilaterally. Another participant may have the formal authority to approve the request while depending on the applicant's practical knowledge. Joint decision procedures, veto powers, reciprocal commitments, and possibilities for review affect which transitions can be realised. Accordingly, effective control capacity need not imply domination of other participants. In some circumstances it is exercised through reliable rights of participation, refusal, appeal, or withdrawal. Whether these rights are effective depends on enforceability, available information, response times, and the costs borne by those invoking them.

The governance significance of external relationships is similarly conditional. Section 5 considered how one relationship may supply resources or knowledge useful in another. A stable employment arrangement, for example, could provide income that permits sustained research elsewhere; an external professional association could create new opportunities to negotiate responsibilities within the employing organisation. Those possibilities depend on material conditions, including contractual limits, working hours, confidentiality duties, and the reliability of external partners. An expectation that external resources will become available later does not supply the resources required to survive a present shortfall. By the same reasoning, predictable income does not preserve other opportunities when its acquisition requires obligations that leave them inaccessible. The mechanisms of replenishment, portability, and crowding-out must be examined rather than inferred from institutional labels.

Governance decisions also have different temporal profiles. A short-term reduction in uncertainty may be valuable when reserves are close to exhaustion. The same arrangement, if reproduced without review, could increase dependence on a specific decision-maker or diminish transferable skills. Conversely, an uncertain experiment might initially impose learning and coordination costs while later producing a more reliable procedure; it might also fail and destroy a reserve needed for future participation. The present inquiry offers no general ordering of these paths. It suggests comparing the timing of obligations and benefits, the possibility of revising commitments, and the degree to which early decisions restrict or enlarge feasible later actions. The latter comparison requires attention to options that remain practically available, not merely to hypothetical paths that can be described after the fact.

A relevant distinction is between *preserving an option* and *continually exercising it*. An actor may benefit from retaining access to retraining, outside collaboration, or a formal grievance process without needing to change professions, undertake a new collaboration, or lodge an appeal. Such access can support stable work by making adjustment credible when circumstances change. However, an option that requires sustained membership fees, attention, or unpaid labour is not costless to preserve. Its value also depends on the quality and independence of the institutions that sustain it. This distinction provides a way of considering stability and openness together without defining perpetual experimentation as a governance objective. March's discussion of exploration and exploitation offers an established account of the intertemporal tension between learning and established practice [9].

At the collective level, institutional rules can distribute the costs of maintaining such possibilities unevenly. A manager may approve innovations while assigning their preparatory work to employees

with little discretion over workload. An organisation may retain the benefits of a jointly developed procedure while another participant bears the continuing burden of updating it. A network may increase available collaborations for some members while excluding those unable to contribute unpaid time. The governance analysis therefore requires a distributional account of control over rule revision, access to resources, exposure to disturbances, recognition of contributions, and the ability to exit without disproportionate loss. Institutional persistence or aggregate output alone cannot show whether the arrangement is acceptable for its participants. Evaluative judgments additionally require explicit ethical commitments, legal duties where applicable, and attention to affected third parties.

The resulting questions can be addressed through a revisable assessment rather than a fixed ranking of desirable states. For a specified arrangement, an inquiry might identify the actors and tasks at issue, examine what each participant can actually do, estimate ordinary and exceptional demands on resources, and trace how learning or governance changes modify later permissions and opportunities. It can then ask whether an alternative allocation of responsibilities, an appeal mechanism, a resource reserve, or a cooperation agreement would address an identified vulnerability. These examples are possible objects of research and deliberation, not policy prescriptions implied by the model. A governance intervention that improves one task can worsen another; the assessment must retain that trade-off and make the normative criteria visible.

This approach also treats governance practices as part of the evolution under study. Ostrom's account of polycentric arrangements highlights learning and coordination across decision centres, while offering no reason to expect that multiplying institutions alone resolves collective-action problems [11]. In the present actor-relative setting, institutional diversity may permit a measure of independence or provide alternative channels for learning. It may equally add incompatible procedures and cumulative obligations. Governance shapes the possibilities and costs of adjustment, but its own rules can subsequently be challenged, revised, copied, or abandoned. The particular sequence, and the power to influence it, are proper subjects for historical investigation.

6.2 Scope, Limitations, and Further Inquiry

The paper joins several established bodies of thought in a discussion of a specific governance question. It does not demonstrate that social institutions generally possess mathematically identifiable attractors, bifurcation parameters, or critical points. Nonlinear dynamics supplies precise concepts where a state, evolution law, disturbance process, and appropriate observational evidence can be specified. At the more general level of institutional interpretation, the terms *lock-in*, *disturbance*, and *transition* identify possible patterns and processes whose empirical content must be established separately. Claims about critical slowing down, for example, cannot be extended from a known dynamical model to organisational history merely because a period of institutional change appears turbulent [13, 15].

The formal control representation also has deliberately narrow scope. Equation 2 describes a reduced state, structural conditions, a focal intervention, a disturbance, and a resource account. Its functions have not been estimated. The scalar reserve is an illustrative accounting simplification, and the paper has repeatedly distinguished material reserves from legal permissions, expertise, attention, and trust. Those conditions cannot generally be exchanged at a common price. The robust feasibility formulation in Equation 3 further relies on selected target and admissible sets, an information structure, a disturbance class, and a time horizon. A different specification can yield a different answer about the same actor's capacity. This dependence is part of the definition's purpose: a task-relative capacity should not be misrepresented as an enduring, universal measure of personal authority or political power. The relevant technical literature distinguishes reachability, stabilisation, and viability under explicit assumptions [14, 2].

A model of a focal actor can also obscure the agency of others. Classifying an employer's response or a collaborator's decision as an external disturbance is convenient for a bounded control task, yet that representation has limited use for questions concerning negotiation, consent, responsibility, or reciprocal governance. Each participating actor may have distinct goals, information, capacities, and rights.

Collective decisions can change those properties and the institutions through which they are expressed. Analyses of such questions may require multi-actor, historical, or interpretive approaches that preserve the relevant participants' perspectives. A simplified dynamical equation cannot decide which participants ought to have authority or how their interests should be weighed.

The idea of a *generative landscape* has an additional representational limit. Equation 8 offers a provisional actor-relative organisation of feasible configurations, transitions, resources, and institutional conditions. It does not assume a single fitness measure or a universal ranking of histories. Existing work on adaptation, organisational learning, and path dependence already provides sophisticated landscape and evolutionary accounts [8, 10, 1]. The present discussion makes no claim of novelty or intellectual priority for its vocabulary, the linkage of mechanisms, or its relational framing. Its possible usefulness lies in the questions it makes convenient to pose together, subject to demonstrated clarity and relevance in future work. The representation would lose explanatory value if its components were left indefinitely unspecified or were treated as an explanation merely because they could be named.

The word *generative* also invites normative overreach. More available paths, more organisational novelty, or faster adaptation do not necessarily improve the lives or rights of those affected. A newly available arrangement may be exploitative; a stable institution may preserve essential care or due process; a costly transition may transfer burdens to others. Empirical access to a path must be distinguished from its desirability, and institutional legitimacy must be assessed with standards that the landscape vocabulary does not itself supply. Likewise, a system's continued operation is compatible with the depletion of resources held by some of its members. Studies of a generative landscape would need to specify both whose feasible possibilities are being described and how costs and benefits are distributed over time.

Several forms of further research follow from these limits. A modest organisational study could begin with an identified decision or rule change and follow how permissions, work demands, resource reserves, and accessible external relationships evolve. Interviews and documentary records might clarify what actors understand as feasible, while employment conditions and process histories could help assess whether those understandings correspond to enforceable permissions or dependable resources. Where suitable longitudinal measurements exist, researchers could evaluate changes in transition costs or exposure to disruption. Such an evaluation would require careful handling of selection effects, institutional context, delayed consequences, and plausible alternative explanations. It should not infer a bifurcation from anecdotal descriptions of change.

Formal and computational research could proceed separately. A restricted simulation might represent a few actors with explicit intervention rights, a finite stock of resources, and rules for learning, cooperation, and institutional revision. Its use would be to test the internal consequences of stated assumptions and to identify potentially discriminating observations, not to establish that a particular workplace follows the simulated trajectories. Similarly, an empirically grounded control problem could compare regulatory and transformative tasks under defined disturbance bounds. Neither method replaces historical inquiry into why the rules and permissions took their present form. Evolutionary economics and studies of institutional persistence offer existing resources for this inquiry, including accounts of routines, path dependence, and multi-level change [4, 12, 3].

In terms of Generative Relational Theory, the proposed analysis primarily concerns historically formed relational structures and their causal and practical consequences. Observed decisions, contracts, procedures, and accounts of cooperation provide situated manifestations through which such relations may be studied. The discussion leaves ultimate ontological questions open. Its equations are research representations, not an assertion that the underlying social reality is identical with the chosen state variables. More generally, no single research mode is presumed to absorb the others: formal modelling, historical interpretation, institutional comparison, and normative reasoning address partially distinct aspects of the governance problem.

6.3 Criticality, Controllability, and Historical Choice

The question posed in the title arose from two concerns. An actor with little effective control may face recurring disturbances whose costs deplete the resources needed to remain active. An actor with considerable control over a stable routine may, under different conditions, become increasingly dependent on that routine and face growing costs of change. Both possibilities are consequential for governance, yet neither supplies a universal recommendation. The consequences of regulation and experimentation depend on what is being controlled, the relation within which the intervention takes place, the available reserves, and the historically changing options for adjustment.

Treating the two concerns as rival priorities would conceal a further possibility. The resources that support present stability can also support later exploration; learning undertaken in an uncertain relationship can subsequently expand regulatory capacity; and participation across several systems can sometimes make otherwise unavailable transitions feasible. Conversely, obligations can spill across those same systems, exhausting reserves or concentrating dependence. The mechanisms need not unfold in the same sequence, and their consequences need not be uniform across the actors involved. The analysis therefore has reason to follow histories of interaction, not simply to locate each organisation at a fixed point on an imagined scale of openness or control.

A similar restraint applies to the metaphor of a return to criticality. Where a particular dynamical model has an identifiable transition threshold, the conditions for approaching it may be studied formally. In a changing institutional environment, however, past transition opportunities may no longer exist in the same form. People, rules, knowledge, and relationships may have changed, altering both the desirable tasks and the paths by which they could be pursued. A future opportunity may emerge through an arrangement that was previously unavailable. Describing the history solely as movement toward or away from an earlier point can miss the formation of these different possibilities. The historically changing landscape concerns the transformation of feasible relations themselves.

The resulting governance consideration is modest. When judging an arrangement, it may be useful to ask how present benefits are sustained, which actors absorb disturbances and transition costs, what kinds of revision remain feasible, and which alternative relations can be mobilised without undermining essential obligations. These questions support comparison and revision under uncertainty. They do not yield a universal objective function, guarantee that preserving more options is always preferable, or justify imposing instability upon others in the name of future generativity. In some contexts reliable protection and predictable obligations deserve immediate emphasis; elsewhere the central problem may be restricted participation or an inaccessible process of institutional change. The relevant conditions remain open to historical and empirical scrutiny.

The paper consequently leaves the opening question unresolved in the sense of providing no general winner between criticality and controllability. It has instead specified why the comparison changes with the actor, task, institutional relationship, resource history, and available paths beyond the focal system. Control capacity can be exercised and altered within those paths; critical conditions may change or cease to be an appropriate description; and the possibilities of subsequent action can be widened or narrowed through the very practices undertaken in the present. A decision is made within a historically formed generative landscape that the decision, together with other actors' responses, may also help to change. The resulting task is to study how decisions and institutional responses alter subsequent feasible choices, including whose resources sustain those changes and whose options contract.

Research Ethics and Source Provenance

Research status. This manuscript is a complete discussion-paper text prepared for independent scholarly circulation, not a peer-reviewed article or an empirically validated governance study. It reports no original human-participant data. All governance scenarios are hypothetical and do not make factual claims about particular institutions.

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