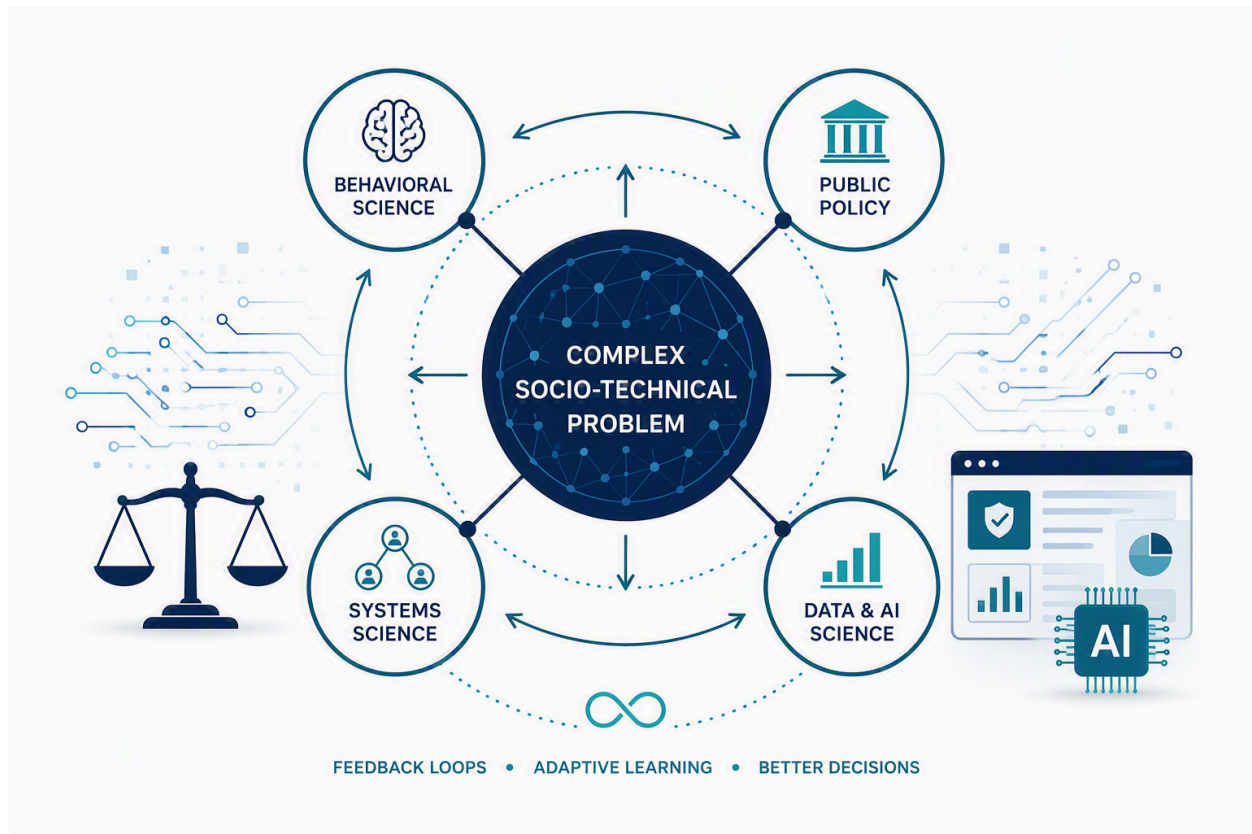


Systems, Nudges, and Networks

Decision-Making for Complex Problem Solving in Socio-Technical Digital Policy



Cover Image

Complex socio-technical governance through systems, nudges, networks, and adaptive learning

Systems, Nudges, and Networks: Decision-Making for Complex Problem Solving in Socio-Technical Digital Policy

Complexity, epistemic pluralism, behavioral regulation, and youth social media governance

Abstract

Institutional decision-making within socio-technical ecosystems increasingly confronts wicked problems: non-linear public challenges marked by uncertainty, shifting boundaries, recursive feedback, and competing stakeholder values. This article examines the conceptual landscape of decision-making for complex problem-solving by distinguishing between complicated domains, where expert analysis can clarify relatively stable cause-and-effect relationships, and complex domains, where decision-makers must learn through iterative intervention. Building on Raadschelders and Whetsell's account of complex public problem resolution, the article conceptualizes decision-making as an epistemic landscape shaped by scientific or disciplinary knowledge, organizational knowledge, societal knowledge, and individual knowledge. It then integrates the Cynefin framework, systems thinking, bounded rationality, nudge theory, and Actor-Network Theory to develop an adaptive model for diagnosing complexity, designing safe-to-fail interventions, and evaluating governance responses. The framework is applied to youth social media policy and the litigation surrounding Ohio's Social Media Parental Notification Act in *NetChoice, LLC v. Yost*. The article argues that effective socio-technical governance cannot rely on predictive control alone; it requires iterative probing, continuous sensing, and responsive orchestration across legal, technological, epistemic, and behavioral networks.

Keywords: complex decision-making, wicked problems, socio-technical governance, Cynefin framework, systems thinking, bounded rationality, nudge theory, choice architecture, Actor-Network Theory, epistemic pluralism, adolescent mental health, platform regulation, social media governance, *NetChoice, LLC v. Yost*

Introduction

Modern public institutions and organizations increasingly operate in environments where conventional linear planning is insufficient. Linear decision-making assumes that problems can be decomposed into relatively stable causes and effects, that expert analysis can identify a defensible solution, and that implementation will produce reasonably predictable outcomes. These assumptions remain useful for complicated problems, such as technical engineering, financial auditing, or logistical optimization. They become unreliable, however, when decision-makers confront complex problems whose variables interact recursively, whose boundaries shift during intervention, and whose outcomes emerge only after action.

Accordingly, the conceptual landscape of complex problem solving requires a shift from prediction to adaptation. Instead of asking only which solution should be implemented, decision-makers must ask what type of problem they face, which feedback loops are active, which human and non-human actors structure the system, and how small interventions can generate information that cannot be obtained in advance. This article argues that socio-technical digital policy is most effective when it treats governance as an adaptive learning process rather than as a one-time exercise in predictive control.

Raadschelders and Whetsell sharpen this diagnosis by arguing that complex public problem resolution is not only a technical challenge but also an epistemic one. Public problems are shaped by competing claims about what counts as relevant knowledge, who has authority to define the problem, and which forms of experience should guide intervention. In their framework, scientific, societal, organizational, and individual knowledge sources interact before a problem can be decomposed into manageable sub-problems. This reorients decision-making away from the search for a single expert answer and toward the pragmatic integration of multiple knowledge claims.

This article contributes to digital policy scholarship by treating youth social media governance as a complex socio-technical decision problem rather than as a discrete legal or behavioral question. Its central contribution is an integrative decision model that links epistemic pluralism, adaptive experimentation, platform choice architecture, and actor-network mediation. This model clarifies why policy interventions in digital environments should be evaluated not only by their formal legal design, but also by the feedback loops, institutional knowledge claims, and technological actants they activate.

The article proceeds in five stages. First, it distinguishes complicated from complex decision contexts. Second, it develops a theoretical framework grounded in epistemic pluralism, systems thinking, bounded rationality, choice architecture, and actor-networks. Third, it situates youth social media governance within the empirical context of adolescent mental health and platform

engagement. Fourth, it analyzes *NetChoice, LLC v. Yost* as a case of socio-technical legal conflict. Finally, it proposes adaptive decision protocols for digital public policy.

Problem Diagnosis: Complicated and Complex Domains

The Cynefin framework offers a sense-making model for distinguishing among decision contexts. Snowden and Boone argue that leaders should tailor action to context: in complicated domains, cause and effect can be clarified through expert analysis; in complex domains, instructive patterns emerge through experimentation rather than prediction (Snowden & Boone, 2007). In complicated settings, the appropriate sequence is sense-analyze-respond: gather facts, apply expertise, and implement the best available technical solution. In complex settings, the sequence becomes probe-sense-respond: initiate safe-to-fail experiments, observe the system's reaction, and amplify or dampen emergent patterns.

This distinction has important implications for public governance. When complex problems are treated as merely complicated, decision-makers tend to produce rigid plans, overstate the predictive capacity of expert analysis, and postpone learning until implementation failure becomes visible. Wicked problems—such as climate adaptation, public health communication, platform governance, and adolescent digital well-being—do not yield durable solutions through singular interventions. They require adaptive feedback, institutional humility, and repeated cycles of policy learning. Figure 1 summarizes this contrast by placing the linear trajectory of complicated problem solving alongside the cyclical, feedback-dependent trajectory of complex problem solving.

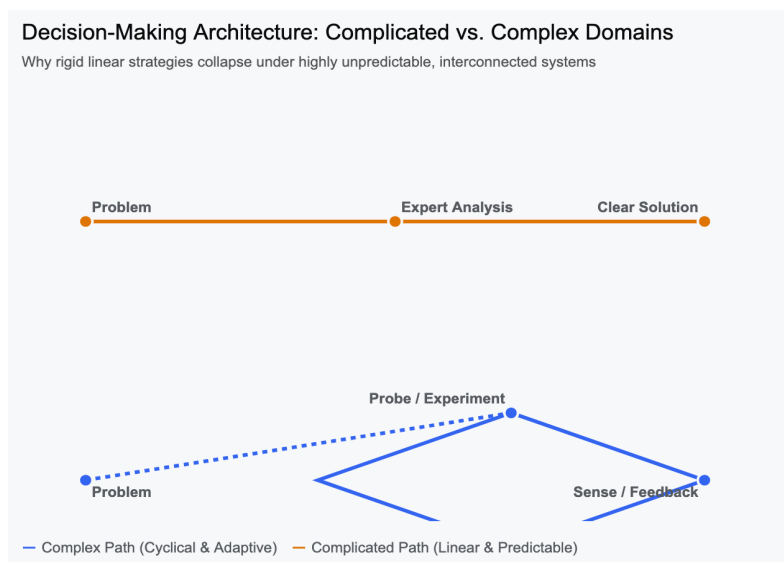


Figure 1
Decision-Making Architecture for Complicated and Complex Problem Domains

This distinction also clarifies the connection between Cynefin and Integrated Media Literacy's core framework. The *probe-sense-respond* sequence that Cynefin prescribes for complex institutional problems is structurally analogous to the habit loop that Integrated Media Literacy asks of an individual reader: rather than presume that the answer is already known, one first gathers signal and then acts. *Pause → Verify → Contextualize → Participate* is therefore *probe-sense-respond* scaled down to the level of an individual evaluating a single claim, while Cynefin scales the same discipline up to the level of an institution evaluating a policy. Both frameworks reject the same failure mode: treating a fast-changing, interactive system as though it were static, fully knowable, and controllable in advance. This shared logic prepares the theoretical framework that follows, where complex decision-making depends on integrating multiple forms of knowledge before institutional action can become responsible.

Theoretical Framework

Knowledge Sources in Complex Public Problem Resolution

Raadschelders and Whetsell identify four knowledge sources that shape decision-making around complex public problems: **scientific or disciplinary knowledge**, **organizational knowledge**, **societal knowledge**, and **individual knowledge** (Raadschelders & Whetsell, 2018). **Scientific or disciplinary knowledge** is produced through specialized research communities and formal evidentiary standards. **Organizational knowledge** is embedded in institutional strategies, rules, routines, procedures, and memory. **Societal knowledge** arises from shared histories, values, norms, ideologies, and social movements. **Individual knowledge** reflects lived experience, moral judgment, personal motivation, tacit understanding, and practical habit. Complex decision-making requires attention to all four sources because no single epistemic standpoint can fully define, decompose, or resolve a wicked problem.

These knowledge sources may interact collaboratively, agnostically, or adversarially. Interaction is **collaborative** when different sources reinforce one another and enable coordinated problem decomposition. It is **agnostic** when relevant knowledge is ignored, unavailable, or treated as irrelevant. It is **adversarial** when one source actively contests, suppresses, or strategically undermines another. This typology is especially useful for socio-technical policy, where scientific evidence about harm, organizational incentives for engagement, societal values concerning autonomy, and individual experiences of risk frequently coexist without converging into a single decision premise.

Systems Thinking and Feedback Loops

Systems thinking reframes problems as patterns within interconnected structures rather than isolated events. In socio-technical systems, an intervention targeting one node—such as a legal Systems, Nudges, and Networks

requirement, platform design feature, school policy, or parental control—can produce unintended consequences elsewhere. Reinforcing loops accelerate behavior and can produce runaway effects, while balancing loops resist change and return a system toward equilibrium. Decision-makers must therefore identify leverage points: locations where relatively small interventions can generate disproportionate and sustainable change.

Bounded Rationality and Satisficing

Bounded rationality emphasizes that decision-makers operate under limits of time, information, computational capacity, and institutional attention (Simon, 1957). In complex domains, the search for an optimal solution can become counterproductive because the system changes faster than the analysis can be completed. Satisficing—selecting a course of action that meets a defensible threshold of adequacy—becomes a practical strategy for moving from abstract uncertainty to real-world learning. The point is not to abandon rigor, but to redirect rigor toward disciplined experimentation.

Nudge Theory and Choice Architecture

Nudge theory explains how the design of an environment can predictably influence behavior without eliminating choice (Thaler & Sunstein, 2008). In digital spaces, platform interfaces, default settings, recommendation systems, notification architectures, and infinite scroll all operate as choice architectures. Commercial design may encourage prolonged engagement, while regulatory design may create counter-nudges that slow or redirect behavioral patterns. For youth social media policy, the central question is whether public institutions can alter digital choice architectures without imposing constitutionally impermissible restrictions on expression.

Actor-Network Theory and Socio-Technical Mediation

Actor-Network Theory expands the field of analysis by treating human and non-human entities as actants within a network (Latour, 2005). Lawmakers, parents, adolescents, judges, algorithms, smartphones, age-verification tools, data servers, and terms-of-service contracts all participate in shaping policy outcomes. Under this view, a digital platform is not merely a passive forum for speech; it is an active mediator that translates incentives, attention, identity, and behavior into socio-technical arrangements. Policy failure occurs when institutions regulate one visible actor while ignoring the networked actants that adapt around the intervention.

Empirical Context: Adolescent Mental Health and Social Media Engagement

The empirical motivation for state intervention is grounded in growing concern about adolescent mental health and platform engagement. Pew Research Center reported in 2025 that 45% of U.S. teens said they spend too much time on social media, compared with 36% in 2022; the same report found that teen girls were more likely than boys to say social media they used affected their mental health, confidence, or sleep (Faverio, Anderson, & Park, 2025). These findings do not establish a single causal pathway, but they identify a policy-relevant association: adolescent well-being is entangled with user experience design, peer dynamics, parental oversight, data extraction, and legal definitions of platform responsibility.

From a systems perspective, adolescent platform use can be interpreted as a reinforcing loop. Greater engagement produces more behavioral data; additional data improve personalization; improved personalization increases relevance and salience; and increased salience extends engagement. This attention economy dynamic can create ethical concerns when platform incentives encourage habitual or addictive patterns of use (Bhargava & Velasquez, 2021). Regulatory interventions seek to interrupt this loop, but they may also activate balancing or displacement effects, such as migration to less regulated services, parental resistance to surveillance, or design changes that preserve engagement while formally complying with the law.

Case Study: Ohio's Social Media Parental Notification Act and *NetChoice, LLC v. Yost*

Ohio's Social Media Parental Notification Act, codified at Ohio Rev. Code § 1349.09, requires certain social media operators to obtain verifiable parental consent before children under sixteen can enter into contracts to use covered services (Ohio Social Media Parental Notification Act, 2026). In *NetChoice, LLC v. Yost*, the litigation provides a concrete example of decision-making under complexity: lawmakers attempted to redesign digital choice architecture, platforms challenged the intervention as a First Amendment burden, and the judiciary became a macro-level balancing mechanism for determining which network configurations were legally permissible (*NetChoice, LLC v. Yost*, 2026).

The litigation also illustrates how legal categories shape socio-technical governance. NetChoice argued that parental consent requirements chilled minors' access to protected speech and imposed unconstitutional burdens on online expression. The Sixth Circuit, however, emphasized limits on third-party standing and concluded that NetChoice had not shown the Act was facially

unconstitutional (*NetChoice, LLC v. Yost*, 2026). Conceptually, the dispute turns on whether platform account creation should be treated primarily as expressive access to a public forum or as a commercial transaction involving minors, contracts, data extraction, and platform design.

Discussion: Decision Protocols for Complex Digital Policy

The case study suggests that digital policy should be designed as a portfolio of adaptive probes rather than as a single definitive solution. A probe-sense-respond protocol would begin with narrow, transparent, and empirically measurable interventions: privacy-protective defaults, age-appropriate notification limits, parental mediation tools, independent auditing of engagement-maximizing features, and sunset clauses requiring periodic reassessment. Decision-makers would then monitor outcomes across multiple indicators, including adolescent well-being, speech access, privacy risks, platform compliance costs, litigation outcomes, and displacement to alternative services.

For technology and AI leaders, the framework extends the article's policy analysis to enterprise AI governance. Complex AI deployments cannot be understood solely through data quality, model performance, or engineering optimization because production environments are also structured by organizational routines, legal obligations, social expectations, user practices, and ethical judgment (National Institute of Standards and Technology, 2023; Xu & Gao, 2024). Raadschelders and Whetsell's knowledge-landscape model therefore positions AI governance as a problem of multi-knowledge orchestration: technical systems must align with institutional workflows, regulatory constraints, public norms, and situated human expertise. The implication is that enterprise AI problems should be decomposed into manageable modules, tested through safe-to-fail interventions, and refined through continuous feedback so that code, policy, and human behavior co-evolve within the same socio-technical system (National Institute of Standards and Technology, 2023; Xu & Gao, 2024).

Food-price crises provide a useful cross-domain test of the article's adaptive governance model because they expose the risk of treating a complex system as a simple affordability problem. IMF guidance begins with a diagnostic sequence—availability, affordability, market functioning, and targeting capacity—before recommending instruments such as in-kind transfers, vouchers, cash assistance, subsidies, or import measures. The 2026 U.S. beef intervention illustrates why that sequence matters. The White House temporarily expanded access to lean beef trimmings by up to 300,000 metric tons over 90 days, administered in three monthly tranches beginning September 1, 2026, and framed the action as a targeted response to elevated ground-beef prices and tight domestic supply. Yet the same policy also activated producer-side feedback loops: USDA reported tighter calf supplies, upward revisions to beef imports, and weaker cattle-price data, while NCBA warned that lower market signals could discourage herd rebuilding after

drought, high input costs, and historically low cattle inventories. Purdue agricultural economists further complicate the substitution story by noting that imported lean processing beef is often a complement to, rather than a direct substitute for, domestic fed-cattle beef because it is blended with higher-fat domestic trim to produce ground beef. The analytical lesson is not that imports are categorically inappropriate, but that crisis interventions must be evaluated across retail prices, producer incentives, processing structure, herd-rebuilding dynamics, and exit discipline. Consistent with complex-systems governance, temporary food-price measures should therefore include targeting rules, fiscal monitoring, market-impact surveillance, and explicit sunset conditions so that short-run consumer relief does not unintentionally weaken long-run domestic supply resilience.

This adaptive approach does not eliminate constitutional limits or ethical dilemmas. Rather, it makes them visible as part of the system. Courts, administrative agencies, families, schools, platforms, and adolescents each possess partial knowledge and partial power. Effective governance therefore depends on institutional learning across levels: macro-level constitutional doctrine, meso-level state regulation, and micro-level local practices such as school phone policies. Because courts have recognized minors' First Amendment interests in access to protected expression, youth digital policy must also account for constitutional constraints when regulating platform access and design (Brown v. Entertainment Merchants Association, 2011).

Figure 2 extends the same argument by depicting complex public problem resolution as a knowledge-driven and time-sensitive process. The diagram shows that public problems are shaped by organizational, disciplinary, individual, and social knowledge before being translated through new publications, evaluations, technologies, legal norms, procedures, and lived experience. In this sense, complex decision-making is not simply a matter of selecting among alternatives; it is a recursive process through which institutions learn, adapt, and reconfigure problems over time.

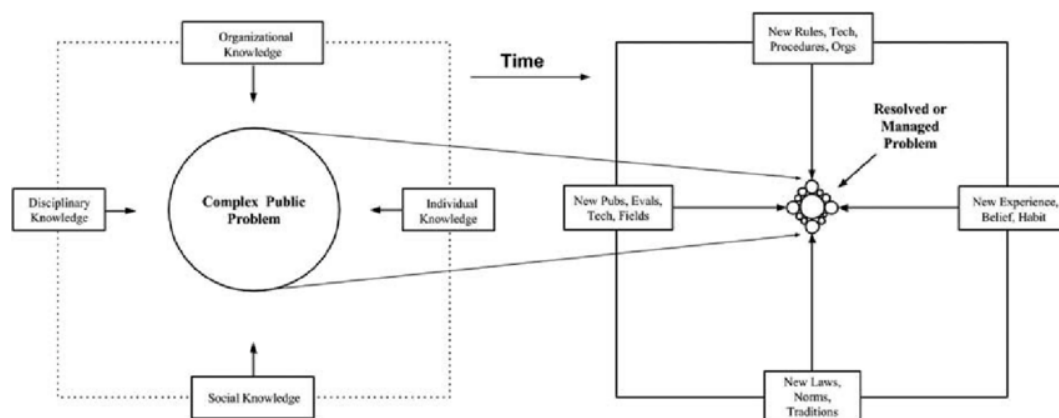


Figure 2
Context of Complex Public Problem Resolution

Figure 3 synthesizes the manuscript’s decision model by connecting problem diagnosis, epistemic mapping, experimental probing, feedback interpretation, and adaptive institutional response.

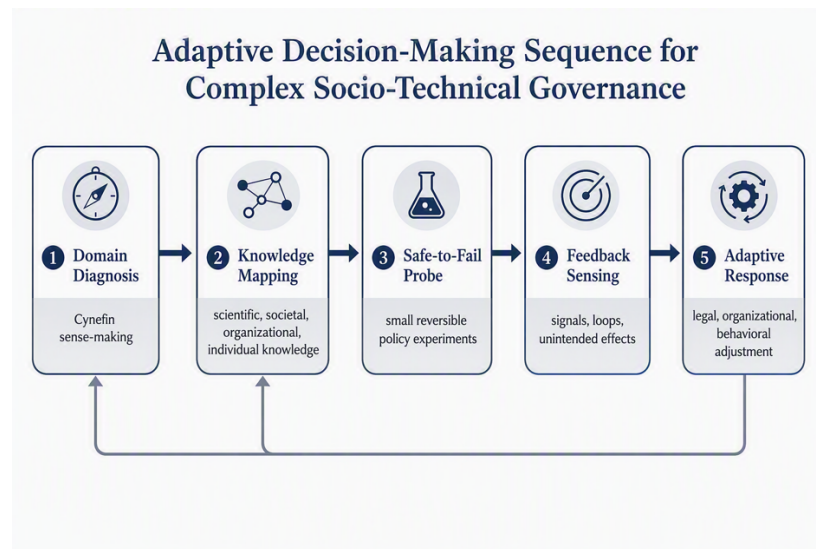


Figure 3
Adaptive Decision-Making Sequence for Complex Socio-Technical Governance

Conclusion

The conceptual landscape of decision-making for complex problem solving requires an institutional shift from expert prediction to adaptive strategy. In complicated domains, expertise and analysis can clarify relatively stable causal relationships and support defensible solutions. In complex domains, however, decision-makers must accept uncertainty, map interdependencies, design safe-to-fail experiments, and learn from emergent feedback. Youth social media policy demonstrates why this distinction matters. Adolescent mental health, platform architecture, constitutional doctrine, parental authority, and commercial incentives form a socio-technical network that cannot be governed through linear command alone.

Methodologically, the article’s framework treats complex governance as a disciplined sequence of contextual diagnosis, epistemic mapping, bounded intervention, feedback interpretation, and institutional recalibration. Cynefin distinguishes contexts in which expert analysis can resolve uncertainty from contexts in which knowledge emerges only through safe-to-fail probing (Snowden & Boone, 2007). Raadschelders and Whetsell’s epistemic landscape specifies how disciplinary, organizational, societal, and individual knowledge claims structure problem definition and decomposition (Raadschelders & Whetsell, 2018). Systems thinking and adaptive management further clarify why interventions must be evaluated as changes to stocks, flows, feedback loops, delays, and leverage points, rather than as isolated regulatory acts (Holling,

1978; Meadows, 2008). Bounded rationality, nudge theory, and Actor-Network Theory add complementary precision by locating policy failure in cognitive limits, choice architectures, and the mediating agency of human and non-human actants (Latour, 2005; Simon, 1957; Thaler & Sunstein, 2008). The article's cases—youth social media regulation, enterprise AI, and food-price intervention—therefore support a systems-governance claim: institutions are effective in complex domains not when they maximize ex ante control, but when they develop procedural capacity to classify the problem context, pluralize knowledge inputs, test bounded interventions, monitor cross-level feedback, and revise rules before compensating dynamics harden into policy failure.

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