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A Computational Systems Model of Multi-Level Governance for Human Flourishing

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Posted Date: 11 September 2026

doi: 10.20944/preprints202609.0964.v1

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A Computational Systems Model of Multi-Level Governance for Human Flourishing

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Abstract

Governance operates simultaneously across multiple levels—from local communities to national governments to international institutions—yet most formal governance models treat governance as a single-level phenomenon. This conceptual paper extends the General Governance Success Model (GSM) to account for multi-level governance, providing a computational systems framework for analysing how governance capabilities interact vertically and horizontally across nested scales. The extended model represents governance at L levels, with each level characterized by five coupled capabilities: accountability, institutional competence, social cohesion, strategic continuity, and adaptive learning. The framework formalizes vertical (top-down and bottom-up) and horizontal (peer-to-peer) interactions, cross-level information flows with fidelity matrices, level-specific dynamics with differentiated parameters, and recursive learning processes. Drawing on the Viable System Model's recursion principle, polycentric governance theory, multi-level governance theory, and system dynamics, the model generates testable hypotheses concerning vertical alignment, polycentric governance, cross-level coordination, and recursive learning. The paper further demonstrates the model's empirical applicability through a worked example applying the GSM to Denmark using open-source data from the World Bank, United Nations, V-Dem, and World Justice Project, followed by a summary of comparative analysis findings across 100 countries (with full results in Appendix C). The extended GSM provides a foundation for analysing governance systems in their full institutional complexity, offering both theoretical insights and practical guidance for designing more effective multi-level governance arrangements. The framework treats computational methods as decision-support tools rather than substitutes for political judgment, with normative objectives and model weights remaining subject to public deliberation, constitutional rights, transparency, and contestability.

Keywords: multi-level governance; complex adaptive systems; dynamical systems; polycentric governance; viable system model; system dynamics; human flourishing; bounded rationality

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1. Introduction

1.1. The Challenge of Multi-Level Governance

Governance does not occur at a single level. It operates simultaneously across nested scales: local communities, municipal governments, regional authorities, national states, and supranational institutions. Each level has distinct capabilities, constraints, and functions, yet they are deeply interconnected through vertical and horizontal relationships. Policy decisions at one level constrain or enable decisions at others; information flows across levels; legitimacy and accountability are distributed; and crises cascade through the system.

Despite this multi-level reality, most formal governance models treat governance as a single-level phenomenon. They assume a unified state, a single set of institutions, or a homogeneous governance system. This simplification obscures the complexity of real governance systems and limits our ability to understand how governance capabilities interact across scales to influence human flourishing.

 doi:10.20944/preprints202609.0964.v1

1.2. The Computational and Systems Perspective

This paper extends the General Governance Success Model (GSM) to account for multiple levels of governance. The GSM is a systems-theoretical metamodel that represents governance as a complex adaptive and information-processing system composed of five interacting institutional capabilities—accountability, competence, social cohesion, strategic continuity, and adaptive learning—whose dynamic configuration and contextual alignment determine the capacity of a governance system to promote sustainable human flourishing (Wang, 2026).

The extension draws on five intellectual traditions:

1. **The Viable System Model (VSM):** Beer's (1972, 1979) cybernetic framework for organizational viability is inherently recursive, recognizing that viable systems contain viable systems within them. This recursion principle applies to governance: each level of governance contains the same essential functions as the whole.
2. **Polycentric Governance Theory:** Ostrom (1990, 2010) and colleagues (Baldwin et al., 2024; Morrison et al., 2023) have demonstrated how multiple, interdependent centres of decision-making can address complex collective action problems.
3. **Multi-Level Governance Theory:** Hooghe and Marks (2001, 2003) developed the foundational framework for understanding governance across multiple levels, distinguishing between Type I (general-purpose, non-overlapping jurisdictions) and Type II (task-specific, overlapping jurisdictions) governance arrangements.
4. **System Dynamics and Complex Adaptive Governance:** Forrester's (1961, 1969) stock-and-flow modelling provides tools for understanding feedback processes. Building on this tradition, complex adaptive governance scholars (Holling, 2001; Gunderson & Holling, 2002; Folke et al., 2005) have examined how governance systems adapt to changing conditions. Recent research has further demonstrated how adaptive governance strategies can address resilience challenges (Morgan et al., 2023; Saikia & Jiménez, 2023).
5. **Network Governance:** Provan and Kenis (2008) and Klijn and Koppenjan (2016) have demonstrated how network structures shape governance effectiveness, complementing the matrix-based formalization of horizontal interactions.

1.3. The Primary Contribution

The central contribution of this paper is a **multi-level extension of the General Governance Success Model** that formalizes how governance capabilities interact vertically and horizontally across nested scales. The extended model provides:

1. A formal state-space representation of governance at multiple levels
2. Vertical and horizontal interaction matrices capturing cross-level influences
3. Multi-level information flows with fidelity across scales
4. Level-specific dynamics with differentiated parameters
5. Cross-level misalignment measures, distinguishing constructive from destructive misalignment
6. Aggregated governance performance and flourishing metrics
7. Testable hypotheses for empirical validation
8. Falsifiability criteria
9. A worked example demonstrating empirical application (Denmark)
10. Summary findings from comparative analysis across 100 countries, with full results in Appendix C

1.4. Research Questions

This paper addresses five principal research questions:

1. How can governance systems be formally modelled at multiple levels?
2. How do vertical and horizontal interactions shape governance performance?
3. How do information flows and fidelity vary across governance levels?

4. What conditions enable effective multi-level governance?
5. How can multi-level governance performance be benchmarked and validated?

2. Research Gap and Contribution

2.1. Limitations of Existing Governance Frameworks

Existing governance frameworks typically assume a single level of analysis. Democratic theory (Dahl, 1971; Mansbridge, 2003) focuses on national-level political institutions. State-capacity research (Evans, 1995; Fukuyama, 2013; Skocpol, 1985) examines national administrative effectiveness. Comparative political economy (Hall & Soskice, 2001; Rodrik, 2000) compares national institutional arrangements. Human-development research (Sen, 1999; Stiglitz et al., 2009; UNDP, 2022) measures national-level well-being.

Recent scholarship on polycentric governance has advanced understanding of how multiple, interdependent centres of decision-making can address complex collective action problems (Baldwin et al., 2024; Morrison et al., 2023). However, this literature has largely focused on environmental and natural resource governance rather than developing a general computational framework for comparative governance evaluation. Similarly, behavioural public administration research has illuminated how cognitive biases, trust, and administrative burden shape citizen-state interactions (Grimmelikhuijsen et al., 2017; Jilke et al., 2024; Alon-Barkat & Busuioc, 2024), but has not been systematically integrated with formal governance-system models.

These single-level approaches have generated valuable insights, but they cannot capture the complexity of real governance systems. Policy implementation occurs at lower levels, while strategic direction is set at higher levels. Coordination failures may arise between levels. Legitimacy is distributed across levels. Crises cascade through the system. Single-level models cannot account for these multi-level dynamics.

2.2. The Systems and Cybernetics Heritage

Beer's (1972, 1979) Viable System Model (VSM) provides a cybernetic framework for organizational viability based on five recursive systems:

Table 1. Viable System Model (VSM) to GSM Dimension Mapping.

VSM System	Function	GSM Dimension (Analogue)
System 1: Implementation	Operational capability	Competence
System 2: Coordination	Conflict resolution and oscillation control	Social Cohesion
System 3: Control	Monitoring, oversight, and resource allocation	Accountability
System 4: Intelligence	Environmental scanning and strategic intelligence	Adaptive Learning
System 5: Policy	Strategic direction and normative closure	Strategic Continuity

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Clarification on the Mapping: The GSM dimensions are conceptual analogues rather than direct one-to-one equivalents of VSM systems. The VSM is an organizational cybernetic framework, while the GSM addresses societal governance. The mapping captures functional correspondences while acknowledging that societal governance involves democratic, behavioural, and normative properties not contained in the organizational VSM. This mapping has been further developed by cyberneticians such as Espejo (1994, 2003), Schwaninger (2004, 2006), and Jackson (2000, 2003), who have extended VSM principles to complex social systems. The GSM thus builds upon this body of work while adding a computational formalization of multi-level governance dynamics.

Forrester's (1961, 1969) system dynamics established stock-and-flow modelling for complex social systems and showed how delays and nonlinear feedback produce counterintuitive outcomes. Checkland's (1981) Soft Systems Methodology recognizes multiple and conflicting worldviews, informing the model's treatment of flourishing as plural and contested. von Foerster's (1974) second-order cybernetics highlights observer dependence in system descriptions and governance indicators. Ashby's (1956) Law of Requisite Variety states that a control system needs sufficient variety to regulate the system it controls. Vickers' (1965) appreciation systems emphasize value-laden judgments about what is desirable and feasible. These traditions collectively inform the multi-level GSM.

2.3. Polycentric Governance

Ostrom's (1990, 2010) polycentric governance theory describes systems with multiple, interdependent centres of decision-making. Key features include:

1. **Multiple decision centres:** No single authority has final control
2. **Overlapping jurisdictions:** Multiple units may have authority over the same territory or issue
3. **Nested scales:** Governance occurs at multiple levels
4. **Vertical interactions:** Higher-level units constrain and enable lower-level units
5. **Horizontal interactions:** Peer units coordinate and compete

Recent research has advanced polycentric governance theory. Baldwin et al. (2024) identified critical gaps in empirical research and proposed a framework for studying long-term change. Morrison et al. (2023) developed the "building blocks" of polycentric governance, identifying key structural and functional elements. These contributions inform the horizontal interaction matrices ($\boldsymbol{H}_\ell$) in the multi-level GSM.

2.4. Multi-Level Governance Theory

Hooghe and Marks (2001, 2003) developed the foundational framework for multi-level governance, distinguishing between two ideal types:

Type I (General-Purpose Governance):

- Non-overlapping, nested jurisdictions
- General-purpose institutions (e.g., local, regional, national governments)
- Stable over time
- Example: Federal systems

Type II (Task-Specific Governance):

- Overlapping, flexible jurisdictions
- Task-specific institutions (e.g., water management districts, transportation authorities)
- Dynamic and evolving
- Example: Functional regions

The multi-level GSM accommodates both types through flexible specification of vertical ($\boldsymbol{T}$, $\boldsymbol{B}$) and horizontal ($\boldsymbol{H}$) interaction matrices. Type I systems would feature stronger vertical alignment and clearer jurisdictional boundaries; Type II systems would feature more complex, overlapping interactions.

 doi:10.20944/preprints202609.0964.v1

2.5. Complex Adaptive Governance

Building on system dynamics and resilience theory (Holling, 1973, 2001; Gunderson & Holling, 2002), complex adaptive governance scholars (Folke et al., 2005; Levin et al., 2013) have examined how governance systems can adapt to changing conditions. Key insights include:

1. **Panarchy:** Systems operate across nested scales, with interactions across levels driving adaptation and transformation
2. **Adaptive cycles:** Systems move through phases of growth, conservation, release, and reorganization
3. **Resilience:** Systems maintain core functions while adapting to disturbances
4. **Transformability:** Systems can fundamentally change when adaptation is insufficient

These insights inform the multi-level GSM's treatment of resilience metrics ($R_{T,\ell}$, $R_{L,\ell}$) and cross-level dynamics. Research on adaptive governance (Morgan et al., 2023; Saikia & Jiménez, 2023) has further demonstrated how governance systems can adapt to changing conditions while maintaining core capabilities. The work of Midgley (2000) on boundary critique and Jackson (2000, 2003) on critical systems thinking further informs the treatment of normative questions and system boundaries.

2.6. Network Governance

Network governance research (Rhodes, 1996; Provan & Kenis, 2008; Klijn & Koppenjan, 2016) examines how policy networks shape governance outcomes. Key contributions include:

1. **Network structures:** Governance networks exhibit different structural properties (centralized, decentralized, distributed)
2. **Network management:** Effective governance requires managing network relationships
3. **Trust and cooperation:** Network effectiveness depends on trust and cooperation among actors
4. **Information sharing:** Networks enable information exchange across organizational boundaries

The multi-level GSM's horizontal interaction matrices ($\boldsymbol{H}_{\ell}$) and information-flow structures ($\boldsymbol{M}_{i,\ell,t}$) draw on this literature.

2.7. Human Flourishing and Well-Being Research

The flourishing dimension ($\boldsymbol{f}_{i,\ell,t}$) builds on established frameworks:

1. **Sen's Capability Approach:** Sen (1999) emphasizes capabilities and functionings—what people are able to be and do
2. **Nussbaum's Central Capabilities:** Nussbaum (2011) identifies ten central capabilities for human flourishing
3. **OECD Better Life Index:** The OECD (2022) measures well-being across multiple dimensions
4. **UNDP Human Development Index:** The UNDP (2022) measures development through health, education, and income
5. **Stiglitz Commission:** Stiglitz et al. (2009) called for broadening well-being measurement beyond GDP

Selection Rationale for the Four Dimensions:

The four flourishing dimensions (e, q, w, n) are not claimed to be exhaustive. They represent a parsimonious synthesis of broader flourishing frameworks selected for analytical tractability while maintaining conceptual breadth. The dimensions are chosen because they:

1. **Capture material and non-material well-being:** Economic prosperity (e) and quality of life (q) cover both material conditions and subjective experiences
2. **Include relational and collective dimensions:** Social well-being (w) captures trust, safety, and inclusion—factors central to social cohesion and governance legitimacy
3. **Incorporate intergenerational considerations:** Sustainability (n) ensures that the framework addresses long-term environmental and intergenerational concerns

4. **Align with major international frameworks:** The dimensions map to the OECD Better Life Index, UNDP Human Development Index, and Stiglitz Commission recommendations
5. **Enable cross-national comparison:** These dimensions are widely measured across countries and levels, facilitating empirical testing

Alternative frameworks (e.g., Nussbaum's ten capabilities, the UN Sustainable Development Goals) could be substituted or incorporated into the framework. The four-dimensional formulation is a baseline chosen for analytical tractability and broad empirical coverage.

Table 2. Flourishing Dimensions and Theoretical Foundations.

Dimension	Definition	Theoretical Foundation	Operationalization
Economic Prosperity (e)	Material well-being, income, employment	Sen (1999), Stiglitz et al. (2009)	GDP per capita, median income, employment rate
Quality of Life (q)	Health, education, subjective well-being	Nussbaum (2011), OECD (2022)	Life expectancy, educational attainment, happiness
Social Well-Being (w)	Trust, safety, opportunity, inclusion	Putnam (1993), Rothstein (2011)	Social trust, safety perceptions, equality
Sustainability (n)	Environmental quality, intergenerational equity	UNDP (2022), Brundtland Commission	Environmental performance, resource efficiency

2.8. The Computational Gap

Despite these advances, the literature lacks:

1. A formal computational framework for multi-level governance
2. Explicit representations of vertical and horizontal interactions
3. Formal models of cross-level information flows
4. Testable hypotheses about multi-level governance dynamics
5. Falsifiable propositions about multi-level governance effectiveness

The multi-level GSM addresses these gaps by providing a formal, testable, computational framework for multi-level governance analysis.

2.9. Why Existing Multi-Level Governance Theory Is Not Enough

This comparison demonstrates that while existing frameworks provide valuable descriptive and conceptual tools, they do not offer the formal, dynamic, computational foundation necessary for rigorous analysis of multi-level governance dynamics.

Table 3. Comparison of Multi-Level Governance Frameworks.

Feature	MLG Theory (Hooghe & Marks)	Polycentric Governance (Ostrom)	VSM (Beer)	Multi-Level GSM
Multi-level structures	✓	✓	✓	✓
Dynamic feedbacks	Limited	Partial	✓	✓
Computational formalization	✗	Limited	✓	✓
Information fidelity	✗	✗	✗	✓
Recursive learning	✗	Limited	✓	✓
State-space dynamics	✗	✗	✓	✓
Human flourishing outcomes	✗	✗	✗	✓
Testable hypotheses	Limited	Limited	✗	✓
Falsifiability criteria	✗	✗	✗	✓

3. Multi-Level State-Space Representation

3.1. Level-Indices and Hierarchical Structure

Define a hierarchy of governance levels $\mathcal{L} = \{1, 2, \ldots, L\}$, where each level represents a distinct scale of governance. For analytical tractability, the model uses a standard five-level hierarchy:

- **Level 1**: Community/local governance
- **Level 2**: Municipal/city governance
- **Level 3**: Regional/state/provincial governance
- **Level 4**: National governance
- **Level 5**: Supranational/international governance

For each level $\ell \in \mathcal{L}$, define the governance state vector:

$$\boldsymbol{g}_{i,\ell,t} = \left[a_{i,\ell,t}, c_{i,\ell,t}, s_{i,\ell,t}, r_{i,\ell,t}, \ell_{i,\ell,t}\right]^{\top} \in \Omega_{\ell} \subseteq \mathbb{R}_{+}^{5}$$

where:

- $a_{i,\ell,t}$: accountability at level ℓ
- $c_{i,\ell,t}$: competence at level ℓ
- $s_{i,\ell,t}$: social cohesion at level ℓ
- $r_{i,\ell,t}$: strategic continuity at level ℓ
- $\ell_{i,\ell,t}$: adaptive learning capacity at level ℓ

Table 4. Governance Capabilities Across Levels.

Capability	Level 1: Community	Level 2: Municipal	Level 3: Regional	Level 4: National	Level 5: Supranational
Accountability	Community meetings, local elections	City councils, local audits	Regional assemblies, state oversight	National parliament, judicial review	International treaties, UN mechanisms
Competence	Local service delivery	Urban planning, public works	Regional coordination	National policy, administration	Global coordination, standard-setting
Social Cohesion	Neighbourhood trust	City identity	Regional identity	National identity	International cooperation
Strategic Continuity	Local plans	City master plans	Regional strategies	National visions	Global frameworks
Adaptive Learning	Local experimentation	City innovation	Regional adaptation	National reform	Global learning

3.2. Level-Specific Feasible Spaces

Each level has its own feasible state space:

$$\Omega_\ell = \{\boldsymbol{g}_{\ell}, \in \mathbb{R}^5 : \boldsymbol{g}_{\ell,\min} \leq \boldsymbol{g}_\ell \leq \boldsymbol{g}_{\ell,\max}\ \boldsymbol{q}_\ell(\boldsymbol{g}_\ell) \leq \mathbf{0}\}$$

where $\boldsymbol{q}_\ell(\boldsymbol{g}_\ell)$ represents coupling, resource, institutional, legal, and normative constraints specific to level ℓ. The selection of governance dimensions is justified by parsimony, coverage, discriminability, and dynamic interaction—the five dimensions capture the essential functions identified in the VSM (Beer, 1972) and state-capacity literature (Fukuyama, 2013), span the governance space, represent theoretically distinguishable functions, and interact in systematic ways that generate governance success or failure (Baldwin et al., 2024; Morrison et al., 2023).

The global feasible space is the Cartesian product:

$$\boldsymbol{\Omega} = \Omega_1 \times \Omega_2 \times \cdots \times \Omega_L$$

3.3. Level-Specific Flourishing

Define flourishing outcomes at each level:

$$\boldsymbol{f}_{i,\ell,t} = \left[e_{i,\ell,t}, q_{i,\ell,t}, w_{i,\ell,t}, n_{i,\ell,t}\right]^\top \in \mathcal{F}_\ell \subseteq \mathbb{R}^4_+$$

where:

- $e_{i,\ell,t}$: economic prosperity at level ℓ
- $q_{i,\ell,t}$: quality of life at level ℓ

 doi:10.20944/preprints202609.0964.v1

- $w_{i,\ell,t}$: social well-being at level ℓ
- $n_{i,\ell,t}$: sustainability at level ℓ

4. Design Principles of the Multi-Level GSM

The multi-level GSM is built upon five core design principles derived from the theoretical foundations:

4.1. Recursion Principle

Derived from Beer's (1972) VSM and elaborated by Espejo (1994, 2003) and Schwaninger (2004, 2006): each governance level contains the same five essential functions as the whole. This justifies the consistent state-space representation across levels.

Formal implication: Each level ℓ has the same governance dimension structure:

$$\boldsymbol{g}_{i,\ell,t} = [a_{i,\ell,t}, c_{i,\ell,t}, s_{i,\ell,t}, r_{i,\ell,t}, \ell_{i,\ell,t}]^\top$$

4.2. Coordination Principle

Derived from polycentric governance (Ostrom, 1990) and network governance (Provan & Kenis, 2008): effective multi-level governance requires both vertical coordination (across levels) and horizontal coordination (across peer units).

Formal implication: Vertical ($\boldsymbol{T}$, $\boldsymbol{B}$) and horizontal ($\boldsymbol{H}$) interaction matrices capture these coordination mechanisms.

4.3. Information Principle

Derived from Ashby's (1956) Law of Requisite Variety and information theory: governance performance depends on information processing capacity across levels, with fidelity varying across scales.

Formal implication: The information-flow matrix $\boldsymbol{M}_{i,\ell,t}$ and fidelity matrices $\boldsymbol{F}_{\ell\to k}$ represent cross-level information processing.

4.4. Adaptation Principle

Derived from complex adaptive governance (Holling, 2001; Folke et al., 2005): governance systems must adapt to changing conditions through learning, feedback, and adjustment.

Formal implication: Adaptive learning capacity $\ell_{i,\ell,t}$ and recursive learning dynamics capture adaptation across levels.

4.5. Flourishing Principle

Derived from Sen (1999), Nussbaum (2011), and well-being research: the ultimate objective of governance is sustainable human flourishing, which is multidimensional and distribution-sensitive.

Formal implication: The flourishing state vector $\boldsymbol{f}_{i,\ell,t}$ serves as the normative objective, with aggregated $HFI_{i,t}$ as the primary performance metric.

5. Vertical and Horizontal Interactions

5.1. Vertical Interaction Matrices

Define vertical interaction matrices representing influence across levels:

Top-Down Influence (Higher to Lower):

$$\boldsymbol{T}_{\ell+1\to\ell} \in \mathbb{R}^{5\times5}$$

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representing how governance at level $\ell + 1$ influences governance at level ℓ. This captures policy mandates, resource allocation, regulatory frameworks, and strategic direction. Top-down influence is derived from VSM's System 5 (Policy) → System 1 (Implementation) recursion.

Bottom-Up Influence (Lower to Higher):

$$\boldsymbol{B}_{\ell-1\to\ell} \in \mathbb{R}^{5\times5}$$

representing how governance at level $\ell - 1$ influences governance at level ℓ. This captures citizen preferences, local innovation, implementation feedback, and political pressure. Bottom-up influence is derived from polycentric governance's recognition of local adaptation and feedback.

The combined vertical influence on level ℓ is:

$$\boldsymbol{V}_{i,\ell,t} = \underbrace{\boldsymbol{T}_{\ell+1\to\ell}\boldsymbol{g}_{i,\ell+1,t}}_{\text{Top-down}} + \underbrace{\boldsymbol{B}_{\ell-1\to\ell}\boldsymbol{g}_{i,\ell-1,t}}_{\text{Bottom-up}}$$

5.2. Horizontal Interaction Matrices

Define horizontal interaction matrices representing coordination across peer-level units at the same governance level:

$$\boldsymbol{H}_{\ell} \in \mathbb{R}^{5\times5}$$

representing how peer units at level ℓ influence each other. This captures coordination, competition, learning, and information sharing. Horizontal interactions are derived from network governance theory (Provan & Kenis, 2008) and polycentric governance's recognition of peer coordination.

The horizontal influence on level ℓ is:

$$\boldsymbol{H}_{i,\ell,t} = \sum\nolimits_{j\in\mathcal{N}_{\ell}(i)} \boldsymbol{H}_{\ell}\,\boldsymbol{g}_{j,\ell,t}$$

where $\mathcal{N}_{\ell}(i)$ is the set of peer units at level ℓ connected to unit i.

5.3. Integrated Interaction Structure

The full interaction structure combines vertical and horizontal influences:

$$\boldsymbol{g}_{i,\ell,t}^{\text{interact}} = \boldsymbol{g}_{i,\ell,t} + \underbrace{\boldsymbol{T}_{\ell+1\to\ell}\boldsymbol{g}_{i,\ell+1,t} + \boldsymbol{B}_{\ell-1\to\ell}\boldsymbol{g}_{i,\ell-1,t}}_{\text{Vertical Interactions}} + \underbrace{\sum\nolimits_{j\in\mathcal{N}_{\ell}(i)} \boldsymbol{H}_{\ell}\,\boldsymbol{g}_{j,\ell,t}}_{\text{Horizontal Interactions}}$$

6. Multi-Level Information Flows

6.1. Multi-Level Information Flows

The information-flow matrix is expanded to include cross-level and cross-unit flows:

$$\boldsymbol{M}_{i,\ell,t} \in [0, 1]^{(5L)\times(5L)}$$

with block structure:

$$\boldsymbol{M}_{i,\ell,t} = \begin{bmatrix} \boldsymbol{M}_{\ell,\ell,t} & \boldsymbol{M}_{\ell,\ell+1,t} & \cdots & \boldsymbol{M}_{\ell,L,t} \\ \boldsymbol{M}_{\ell+1,\ell,t} & \boldsymbol{M}_{\ell+1,\ell+1,t} & \cdots & \boldsymbol{M}_{\ell+1,L,t} \\ \vdots & \vdots & \ddots & \vdots \\ \boldsymbol{M}_{L,\ell,t} & \boldsymbol{M}_{L,\ell+1,t} & \cdots & \boldsymbol{M}_{L,L,t} \end{bmatrix}$$

where:

- $\boldsymbol{M}_{\ell,\ell,t} \in [0,1]^{5\times5}$: intra-level information flows
- $\boldsymbol{M}_{\ell,k,t} \in [0,1]^{5\times5}$: cross-level information flows from level ℓ to level k

6.2. Information Fidelity Across Levels

Information fidelity may vary across levels due to:

1. **Transmission distortion:** Higher levels may receive filtered or summarized information from lower levels
2. **Latency:** Information may take longer to travel across levels
3. **Granularity:** Higher levels operate with more aggregated information
4. **Bias:** Information may be distorted to serve political interests
5. **Loss:** Information may be lost in transmission

Define fidelity matrices:

$$\boldsymbol{F}_{\ell\to k} \in [0,1]^{5\times5}$$

representing the fidelity of information transmitted from level ℓ to level k.

Effective information flow:

$$\boldsymbol{M}_{i,\ell,t}^{\mathrm{eff}} = \boldsymbol{M}_{i,\ell,t} \odot \boldsymbol{F}_{\ell\to k}$$

where $\odot$ denotes elementwise multiplication.

6.3. Information Processing Capacity

Define information processing capacity at each level:

$$C_{i,\ell,t} = \mathrm{tr}\left(\boldsymbol{M}_{i,\ell,t}^{\mathrm{eff}}\right)$$

This captures the total effective information flow at level ℓ.

7. Multi-Level Governance Dynamics

7.1. Coupled Dynamic System with Vertical and Horizontal Interactions

The extended transition equations for each governance level are derived from the GSM's original dynamics (Wang, 2026) and the principles outlined in Section 4:

$$\begin{aligned}\boldsymbol{g}_{i,\ell,t+1} = \Pi_{\Omega_\ell}[(I_5 - \boldsymbol{\Delta}_{g,\ell})\boldsymbol{g}_{i,\ell,t} + \eta_\ell \boldsymbol{B}_{fg,\ell}\boldsymbol{f}_{i,\ell,t-1} + \kappa_{M,\ell}(\boldsymbol{M}_{i,\ell,t}^{\mathrm{eff}} \odot \boldsymbol{A}_{g,\ell})\boldsymbol{g}_{i,\ell,t}^{\mathrm{interact}} \\ - \mu_\ell \boldsymbol{K}_{g,\ell}(\boldsymbol{g}_{i,\ell,t} - \boldsymbol{g}_{i,\ell,t}^{*}) + \boldsymbol{u}_{i,\ell,t} + \boldsymbol{\varepsilon}_{i,\ell,t}]\end{aligned} \tag{1}$$

where:

- $\boldsymbol{\Delta}_{g,\ell} = \mathrm{diag}\left(\delta_{a,\ell}, \delta_{c,\ell}, \delta_{s,\ell}, \delta_{r,\ell}, \delta_{e,\ell}\right)$: level-specific depreciation
- η_ℓ: level-specific flourishing-to-governance reinforcement
- $\boldsymbol{B}_{fg,\ell} \in \mathbb{R}^{5\times4}$: level-specific flourishing mapping
- $\kappa_{M,\ell}$: level-specific information-interaction scale
- $\boldsymbol{A}_{g,\ell} \in \mathbb{R}^{5\times5}$: level-specific interaction matrix
- μ_ℓ: level-specific correction parameter
- $\boldsymbol{K}_{g,\ell} \in \mathbb{R}^{5\times5}$: level-specific adjustment matrix
- $\boldsymbol{g}_{i,\ell,t}^{*}$: level-specific contextual target profile
- $\boldsymbol{u}_{i,\ell,t} \in \mathbb{R}^5$: level-specific policy interventions
- $\boldsymbol{\varepsilon}_{i,\ell,t} \in \mathbb{R}^5$: level-specific disturbances

7.2. Coupled Flourishing Dynamics

Flourishing at each level evolves as:

$$\boldsymbol{f}_{i,\ell,t+1} = \Pi_{\mathcal{F}_\ell}[(I_4 - \boldsymbol{\Delta}_{f,\ell})\boldsymbol{f}_{i,\ell,t} + \zeta_\ell \boldsymbol{C}_{gf,\ell}\boldsymbol{g}_{i,\ell,t-1} - \xi_\ell D_{i,\ell,t}^{*}\boldsymbol{d}_{f,\ell} - \delta_\ell \boldsymbol{S}_\ell \boldsymbol{R}_{i,\ell,t} + \boldsymbol{\nu}_{i,\ell,t}] \tag{2}$$

7.3. Cross-Level Flourishing Spillovers

Flourishing outcomes at one level may influence flourishing at other levels:

 doi:10.20944/preprints202609.0964.v1

$$\boldsymbol{f}^{\text{spillover}}_{i,\ell,t+1} = \boldsymbol{f}_{i,\ell,t+1} + \sum_{k\neq\ell} \boldsymbol{S}_{\ell,k}\, \boldsymbol{f}_{i,k,t}$$

where $\boldsymbol{S}_{\ell,k} \in \mathbb{R}^{4\times 4}$captures flourishing spillover from level $k$to level ℓ.

7.4. Level-Specific Misalignment Measures

Each level has its own context-sensitive misalignment measure:

$$D^{*}_{i,\ell,t} = \sqrt{\left(\boldsymbol{g}_{i,\ell,t} - \boldsymbol{g}^{*}_{i,\ell,t}\right)^{\top} \boldsymbol{W}_{D,\ell} \left(\boldsymbol{g}_{i,\ell,t} - \boldsymbol{g}^{*}_{i,\ell,t}\right)} \tag{3}$$

7.5. Vertical Misalignment: Constructive vs. Destructive

Define vertical misalignment as the mismatch between governance configurations across levels:

$$D^{\text{vert}}_{i,t} = \sum_{\ell=1}^{L-1} \sqrt{\left(\boldsymbol{g}_{i,\ell+1,t} - \boldsymbol{V}_{\ell+1\to\ell}\boldsymbol{g}_{i,\ell,t}\right)^{\top} \boldsymbol{W}^{\text{vert}}_{\ell} \left(\boldsymbol{g}_{i,\ell+1,t} - \boldsymbol{V}_{\ell+1\to\ell}\boldsymbol{g}_{i,\ell,t}\right)}$$

where:

- $\boldsymbol{V}_{\ell+1\to\ell} \in \mathbb{R}^{5\times 5}$maps level $\ell$to level $\ell+1$
- $\boldsymbol{W}^{\text{vert}}_{\ell} \succ 0$weights vertical misalignment

Constructive vs. Destructive Misalignment

While excessive misalignment reduces governance performance, moderate misalignment can be beneficial. The relationship between vertical misalignment and performance is hypothesized to follow an inverted-U curve:

$$Performance_{i,t} = \beta_0 + \beta_1 D^{\text{vert}}_{i,t} - \beta_2 \left(D^{\text{vert}}_{i,t}\right)^2 + \boldsymbol{\chi}^{\top}\boldsymbol{X}_{i,t} + \eta_i + \tau_t + \varepsilon_{i,t}$$

This recognizes that some tension between governance levels can improve resilience, encourage innovation, and prevent excessive centralization.

Constructive misalignment may arise from:

- Federal systems with legitimate autonomy at lower levels
- Separation of powers across levels
- Polycentric governance with overlapping jurisdictions
- Pluralistic systems with multiple centres of authority

Destructive misalignment, by contrast, arises from:

- Policy incoherence across levels
- Conflicting mandates and jurisdictions
- Excessive fragmentation
- Failure of coordination mechanisms

The model distinguishes these types by context: federal systems may benefit from moderate misalignment, while unitary systems may require tighter alignment. Future empirical work should test this distinction.

8. Multi-Level Governance Performance

8.1. Level-Specific Governance Success

Each level has its own governance success function:

$$GS_{i,\ell,t} = \sum_{p=1}^{5} \alpha_{\ell,p}\, g_{i,\ell,p,t} + \sum_{p<q} \kappa_{\ell,pq}\, g_{i,\ell,p,t} g_{i,\ell,q,t}$$

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8.2. Aggregated Governance Success

The overall governance success is a weighted aggregation across levels, with a nonlinear penalty for vertical misalignment reflecting the inverted-U relationship:

$$GS_{i,t} = \sum_{\ell=1}^{L} \omega_\ell \, GS_{i,\ell,t} + \lambda_1 D_{i,t}^{\text{vert}} - \lambda_2 \left(D_{i,t}^{\text{vert}}\right)^2 \tag{4}$$

where

$$\sum_{\ell} \omega_\ell = 1, \omega_\ell \geq 0,$$

$$\lambda_1 > 0$$

captures the potential benefits of moderate misalignment, and

$$\lambda_2 > 0$$

captures the costs of excessive misalignment.

This formulation is consistent with the inverted-U hypothesis in Section 7.5.

8.3. Level-Specific Human Flourishing

$$HFI_{i,\ell,t} = \sum_{k=1}^{4} \gamma_{\ell,k} \, f_{i,\ell,k,t}, \sum_{k} \gamma_{\ell,k} = 1, \gamma_{\ell,k} \geq 0$$

8.4. Aggregated Human Flourishing

The overall human flourishing is a weighted aggregation across levels:

$$HFI_{i,t} = \sum_{\ell=1}^{L} \nu_\ell \, HFI_{i,\ell,t} \tag{5}$$

where

$$\sum_{\ell} \nu_\ell = 1, \nu_\ell \geq 0.$$

9. Causal-Loop Diagram

Figure 1 provides a causal-loop diagram illustrating the key feedback structures in the multi-level GSM.

Figure 1 Legend: The diagram depicts reinforcing loops (R) and balancing loops (B) among governance levels. Solid arrows indicate direct causal influences. Dashed arrows indicate information flows. Each level contains governance capabilities and flourishing outcomes, with vertical (top-down and bottom-up) and horizontal (peer-to-peer) interactions. The feedback loops capture co-evolutionary dynamics within and across levels.

Defined Loops

R1: Governance-Flourishing Reinforcement (Within Level)

Governance Capabilities → Flourishing → Governance Capabilities

This reinforcing loop captures how better governance improves flourishing, which in turn enhances governance capacity.

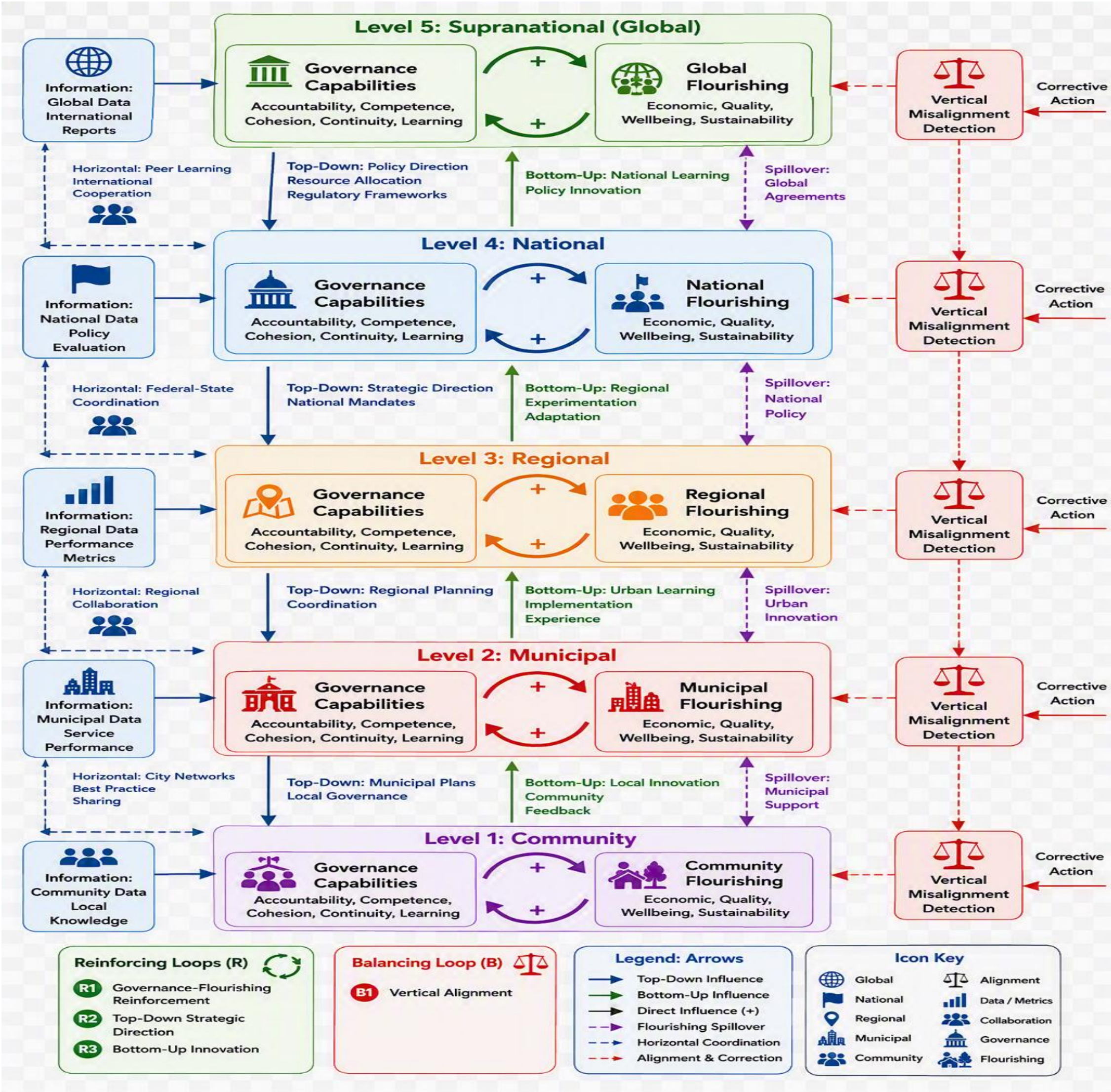

Figure 1. Causal-Loop Diagram of the Multi-Level GSM.

R2: Top-Down Strategic Direction

Higher Level Governance → Lower Level Governance → Lower Level Flourishing
→ Higher Level Flourishing → Higher Level Governance

This reinforcing loop captures how strategic direction from higher levels enables lower-level effectiveness.

R3: Bottom-Up Innovation

Lower Level Governance → Higher Level Governance → Higher Level Flourishing
→ Lower Level Flourishing → Lower Level Governance

This reinforcing loop captures how local innovation informs higher-level policy.

B1: Vertical Alignment

Higher Level Governance → Lower Level Governance → Vertical Misalignment
→ Corrective Action → Reduced Misalignment

This balancing loop captures how vertical misalignment triggers corrective action.

Interpretation

Equilibrium does not imply political consensus, institutional uniformity, or social harmony. Rather, it means dynamic reproduction of governance functions under bounded fluctuations. This interpretation aligns with cybernetic and systems perspectives on stability as dynamic balance rather than static uniformity.

10. Multi-Level Equilibrium and Stability

10.1. Equilibrium Conditions

A multi-level equilibrium $(\boldsymbol{g}_\ell^*, \boldsymbol{f}_\ell^*)$for all $\ell \in \mathcal{L}$satisfies:

$$\boldsymbol{g}_\ell^* = \Pi_{\Omega_\ell}[(I_5 - \boldsymbol{\Delta}_{g,\ell})\boldsymbol{g}_\ell^* + \eta_\ell \boldsymbol{B}_{fg,\ell}\boldsymbol{f}_\ell^* + \kappa_{M,\ell}(\boldsymbol{M}_\ell^{\text{eff}} \odot \boldsymbol{A}_{g,\ell})\boldsymbol{g}_\ell^{\text{interact*}} - \mu_\ell \boldsymbol{K}_{g,\ell}(\boldsymbol{g}_\ell^* - \boldsymbol{g}_\ell^{**}) + \boldsymbol{u}_\ell^*]$$

$$\boldsymbol{f}_\ell^* = \Pi_{\mathcal{F}_\ell}[(I_4 - \boldsymbol{\Delta}_{f,\ell})\boldsymbol{f}_\ell^* + \zeta_\ell \boldsymbol{C}_{gf,\ell}\boldsymbol{g}_\ell^* - \xi_\ell D_\ell^{**}\boldsymbol{d}_{f,\ell} - \delta_\ell \boldsymbol{S}_\ell \boldsymbol{R}_\ell^*]$$

10.2. Stability Conditions

Local stability requires the eigenvalues of the complete transition Jacobian to satisfy:

$$\rho(\boldsymbol{J}^*) < 1$$

where $\boldsymbol{J}^*$is the block-structured Jacobian:

$$\boldsymbol{J}^* = \begin{bmatrix} \boldsymbol{J}_{11} & \boldsymbol{J}_{12} & \cdots & \boldsymbol{J}_{1L} \\ \boldsymbol{J}_{21} & \boldsymbol{J}_{22} & \cdots & \boldsymbol{J}_{2L} \\ \vdots & \vdots & \ddots & \vdots \\ \boldsymbol{J}_{L1} & \boldsymbol{J}_{L2} & \cdots & \boldsymbol{J}_{LL} \end{bmatrix}$$

10.3. Multiple Equilibria Across Levels

The multi-level system may exhibit multiple equilibria due to:

1. **Threshold effects:** Different levels may have different critical thresholds.
2. **Institutional complementarities:** Configurations at one level may require complementary configurations at other levels.
3. **Path dependence:** Historical decisions at higher levels constrain lower-level choices.
4. **Lock-in effects:** Once established, multi-level configurations may be difficult to change.
5. **Regime switching:** Systems may transition between different equilibrium configurations.

11. Multi-Level Control Architecture

11.1. Hierarchical Control with Recursion

The control architecture follows Beer's (1972) VSM recursion levels, as further developed by Espejo (1994, 2003) and Schwaninger (2004, 2006):

Table 5. Hierarchical Control Architecture: GSM Levels, VSM Systems, Functions, and Time Horizons.

GSM Level	VSM System	Function	Time Horizon
Level 5: Supranational	System 5 (Policy)	Global policy coordination	20-50 years
Level 4: National	System 4 (Intelligence)	Strategic direction	10-30 years
Level 3: Regional	System 3 (Control)	Policy implementation	5-15 years
Level 2: Municipal	System 2 (Coordination)	Coordination	3-10 years
Level 1: Community	System 1 (Implementation)	Service delivery	0-5 years

11.2. Control Variables at Each Level

Each level has its own control variables:

$$\boldsymbol{u}_{i,\ell,t} \in \mathbb{R}^5$$

representing policy interventions at level ℓ.

Control Variable Types

1. **Resource allocation:** Budgets, personnel, infrastructure
2. **Regulatory instruments:** Laws, regulations, standards
3. **Information instruments:** Data collection, reporting, transparency
4. **Coordination instruments:** Inter-level communication, joint planning

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5. **Capacity-building instruments:** Training, technical assistance

11.3. Coordination Mechanisms

Top-Down Coordination

$$\boldsymbol{u}_{i,\ell,t}^{\text{top-down}} = \Phi_{\ell+1\to\ell}\boldsymbol{u}_{i,\ell+1,t}$$

Bottom-Up Coordination

$$\boldsymbol{u}_{i,\ell,t}^{\text{bottom-up}} = \Psi_{\ell-1\to\ell}\boldsymbol{u}_{i,\ell-1,t}$$

Peer Coordination

$$\boldsymbol{u}_{i,\ell,t}^{\text{peer}} = \sum_{j\in\mathcal{N}_\ell(i)} \Theta_\ell\, \boldsymbol{u}_{j,\ell,t}$$

Combined Control

$$\boldsymbol{u}_{i,\ell,t}^{\text{total}} = \boldsymbol{u}_{i,\ell,t} + \boldsymbol{u}_{i,\ell,t}^{\text{top-down}} + \boldsymbol{u}_{i,\ell,t}^{\text{bottom-up}} + \boldsymbol{u}_{i,\ell,t}^{\text{peer}}$$

12. Multi-Level Resilience and Adaptability

12.1. Level-Specific Resilience Metrics

Recovery Time at Level ℓ

$$R_{T,\ell} = \min\{k: \|HFI_{i,\ell,t+k} - HFI_\ell^*\| < \epsilon\}$$

Maximum Performance Loss at Level ℓ

$$R_{L,\ell} = \max_{k\geq 0}\left(HFI_\ell^* - HFI_{i,\ell,t+k}\right)$$

Cumulative Loss at Level ℓ

$$R_{A,\ell} = \sum_{k=0}^{K}\left(HFI_\ell^* - HFI_{i,\ell,t+k}\right)$$

12.2. Systemic Resilience

Systemic resilience captures the system's ability to absorb shocks across levels:

$$R_T^{\text{system}} = \min\{k: \|HFI_{i,t+k} - HFI^*\| < \epsilon\}$$

$$R_L^{\text{system}} = \max_{k\geq 0}\left(HFI^* - HFI_{i,t+k}\right)$$

12.3. Adaptability Across Levels

Define level-specific adaptability as:

$$\mathcal{A}_{i,\ell,t} = \frac{\partial \boldsymbol{g}_{i,\ell,t+1}}{\partial \boldsymbol{g}_{i,\ell,t}^*}$$

Systemic adaptability is:

$$\mathcal{A}_{i,t}^{\text{system}} = \sum_\ell \omega_\ell\, \mathcal{A}_{i,\ell,t}$$

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13. Multi-Level Requisite Variety

13.1. Level-Specific Variety

Define governance response variety at level ℓ:

$$V_{G,i,\ell,t} = \text{entropy}(\{\text{policy responses at level } \ell\})$$

Define environmental variety at level ℓ:

$$V_{E,i,\ell,t} = \text{entropy}(\{\text{disturbances at level } \ell\})$$

13.2. Requisite Variety Condition

Ashby's Law requires:

$$V_{G,i,\ell,t} \geq V_{E,i,\ell,t}$$

for effective regulation at each level.

13.3. Multi-Level Requisite Variety

For the multi-level system:

$$RV_{i,t} = \min_{\ell} \frac{V_{G,i,\ell,t}}{V_{E,i,\ell,t}}$$

Values below 1 indicate a systemic regulatory deficiency at some level.

14. Multi-Level Hypotheses

H1: Optimal Vertical Differentiation

Human flourishing is maximized at intermediate levels of vertical differentiation, where governance levels remain sufficiently aligned for coordination while retaining enough autonomy for experimentation and adaptation.

$$HFI_{i,t} = \beta_0 + \beta_1 D_{i,t}^{\text{vert}} - \beta_2 \left(D_{i,t}^{\text{vert}}\right)^2 + \boldsymbol{\chi}^\top \boldsymbol{X}_{i,t} + \eta_i + \tau_t + \varepsilon_{i,t}$$

where $\beta_1 > 0$and $\beta_2 > 0$, yielding an inverted-U relationship.

This formulation recognizes that both extreme alignment (which may suppress innovation and local adaptation) and extreme misalignment (which produces policy incoherence and coordination failures) are suboptimal.

H2: Level-Specific Capability Balance

Balanced capabilities at each level predict higher flourishing, but the optimal balance may vary across levels.

$$HFI_{i,\ell,t} = \beta_{0,\ell} + \beta_{1,\ell} GS_{i,\ell,t} - \beta_{2,\ell} D_{i,\ell,t}^{*} + \boldsymbol{\chi}_\ell^\top \boldsymbol{X}_{i,\ell,t} + \eta_{i,\ell} + \tau_{\ell,t} + \varepsilon_{i,\ell,t}$$

H3: Vertical-Horizontal Interaction

The interaction between vertical alignment and horizontal coordination predicts governance performance.

$$GS_{i,t} = \beta_0 + \beta_1 GS_{i,t}^{\text{vertical}} + \beta_2 GS_{i,t}^{\text{horizontal}} + \beta_3 GS_{i,t}^{\text{vertical}} \times GS_{i,t}^{\text{horizontal}} + \cdots$$

H4: Polycentric Governance Advantage

Systems with distributed authority across multiple levels outperform both fully centralized and fully decentralized systems, but only up to a point.

$$GS_{i,t} = \beta_0 + \beta_1 \text{Polycentricity}_{i,t} + \beta_2 \text{Polycentricity}_{i,t}^2 + \cdots$$

H5: Information Flow and Coordination

Cross-level information flow quality moderates the relationship between vertical misalignment and performance.

$$HFI_{i,t} = \beta_0 - \beta_1 D_{i,t}^{\text{vert}} + \beta_2 M_{i,t}^{\text{cross}} + \beta_3 D_{i,t}^{\text{vert}} \times M_{i,t}^{\text{cross}} + \cdots$$

H6: Recursive Learning

Learning at one level enhances learning at other levels through recursive feedback.

doi:10.20944/preprints202609.0964.v1

$$\ell_{i,\ell,t+1} = \gamma_{0,\ell} + \gamma_{1,\ell}\ell_{i,\ell,t} + \sum_{k\neq\ell} \gamma_{\ell,k}\, \ell_{i,k,t} + \cdots$$

15. Multi-Level Benchmarking and Validation

15.1. Level-Specific Governance Success Index

$$GSI_{i,\ell,t} = \boldsymbol{\alpha}_\ell^\top \boldsymbol{g}_{i,\ell,t} + \sum_{p<q} \kappa_{\ell,pq}\, g_{i,\ell,p,t} g_{i,\ell,q,t}$$

15.2. Aggregated Governance Success Index

$$GSI_{i,t} = \sum_{\ell} \omega_\ell\, GSI_{i,\ell,t} + \lambda_1 D_{i,t}^{\text{vert}} - \lambda_2 \left(D_{i,t}^{\text{vert}}\right)^2$$

15.3. Level-Specific Human Flourishing Index

$$HFI_{i,\ell,t} = \boldsymbol{\gamma}_\ell^\top \boldsymbol{f}_{i,\ell,t}$$

15.4. Aggregated Human Flourishing Index

$$HFI_{i,t} = \sum_{\ell} \nu_\ell\, HFI_{i,\ell,t}$$

15.5. Primary Validation Design

Unit of analysis: Country-year with subnational units
Period: 2000-2025 (multidecade panel)
Governance constructs: Latent variables or transparent composite measures at each level
Outcome: Multidimensional flourishing at each level
Primary model: Dynamic panel or Bayesian multilevel model with cross-level interactions
Baseline comparison: Single-level governance model
Incremental test: Add multi-level interactions, vertical alignment, and cross-level information flows
Validation: Temporal and geographic holdout samples
Causal claims: Explicitly limited unless identification is available

15.6. Falsification Criteria

The multi-level GSM would be challenged if:

1. **Level irrelevance:** Governance at higher levels shows no independent effect on flourishing after controlling for lower levels.
2. **Vertical alignment irrelevance:** Vertical misalignment shows no relationship with performance (linear or non-linear).
3. **Horizontal coordination irrelevance:** Peer-level coordination shows no positive relationship with performance.
4. **Polycentricity non-monotonicity:** Performance shows a strictly monotonic relationship with polycentricity.
5. **Information flow irrelevance:** Cross-level information flow shows no moderating effect on vertical misalignment.
6. **Recursive learning absence:** Learning at one level does not predict learning at other levels.
7. **Level-specific heterogeneity absence:** The optimal balance of capabilities does not vary across governance levels.

 doi:10.20944/preprints202609.0964.v1

16. Empirical Application: Worked Example

16.1. Introduction to the Worked Example

To demonstrate the GSM's empirical applicability and computational procedure, this section presents a complete worked example applying the framework to Denmark using open-source data from the World Bank, United Nations, V-Dem, and World Justice Project.

Denmark is selected because it consistently ranks among the highest-performing governance systems globally, providing an ideal reference point for understanding the GSM methodology and interpretation.

16.2. Data Collection: Raw Indicators for Denmark

Table 6. Denmark: Raw Governance Indicators and Data Sources.

GSM Dimension	Proxy Indicator	Raw Value	Data Source	Year
Accountability	V-Dem Liberal Democracy Index	0.883	V-Dem Institute	2024
Competence	Government Effectiveness Index	2.11	World Bank WGI	2025
Cohesion	WJP Rule of Law Index (Overall)	0.90	World Justice Project	2025
Continuity	Human Development Index (HDI)	0.962	UNDP	2025
Learning	Government Service Satisfaction	72.4%	Our World in Data	2024

16.3. Data Normalization

Normalization Formula (Min-Max)

$$\text{Normalized Score} = \frac{\text{Raw Value} - \text{Theoretical Minimum}}{\text{Theoretical Maximum} - \text{Theoretical Minimum}} \times 100$$

Table 7. Denmark - Normalization Calculations.

GSM Dimension	Raw Value	Minimum	Maximum	Normalized Score
Accountability	0.883	0	1	88.3
Competence	2.11	-2.5	2.5	92.2
Cohesion	0.90	0	1	90.0
Continuity	0.962	0	1	96.2
Learning	72.4%	0%	100%	72.4

16.4. GSM Dimension Scores and Interaction Effects

Baseline Dimension Scores

The five GSM dimension scores form the governance state vector:

$$\boldsymbol{g}_t = [88.3, \ ,92.2, \ ,90.0\ 96.2\ 72.4]$$

Interaction Effects Calculation

The GSM emphasizes that governance dimensions interact nonlinearly. Interaction effects capture complementarities and conflicts between dimensions:

$$\text{Interaction Effect} = \sum_{i<j} \kappa_{ij}\ g_{i,t}\, g_{j,t}$$

Using a theoretical interaction coefficient of

$$\kappa_{ij} = 0.005$$

for positive complementarities:

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Table 8. Denmark: Governance Dimension Interaction Effects.

Interaction Pair	Calculation	Contribution
Accountability × Competence	0.005 × 88.3 × 92.2	**40.7**
Accountability × Cohesion	0.005 × 88.3 × 90.0	**39.7**
Competence × Continuity	0.005 × 92.2 × 96.2	**44.3**
Cohesion × Continuity	0.005 × 90.0 × 96.2	**43.3**
Cohesion × Learning	0.005 × 90.0 × 72.4	**32.6**

$$\text{Total Interaction Effect} = 40.7 + 39.7 + 44.3 + 43.3 + 32.6 = 200.6$$

Interpretation. The positive interaction terms indicate complementarities among governance capabilities. The strongest interaction occurs between **Competence** and **Continuity** (44.3), suggesting that effective administration and long-term strategic stability reinforce one another. Strong complementarities are also observed between **Cohesion** and **Continuity** (43.3) and between **Accountability** and **Competence** (40.7). Collectively, these interactions contribute **200.6 points** to the overall governance success calculation, demonstrating that governance performance depends not only on the strength of individual capabilities but also on how effectively those capabilities interact and reinforce one another.

16.5. Governance Success Index (GSI) Calculation

$$GSI_t = \sum_{i=1}^{5} \alpha_i \, g_{i,t} + \sum_{i<j} \kappa_{ij} \, g_{i,t} g_{j,t}$$

With $\alpha_i = 0.2$:

$$\text{Main Effect} = 0.2(88.3 + 92.2 + 90.0 + 96.2 + 72.4) = 87.8$$

$$\text{Interaction Effect} = 200.6$$

$$\text{GSI (Raw)} = 87.8 + 200.6 = 288.4$$

$$\text{GSI (Normalized)} = \frac{288.4}{1000} \times 100 = \mathbf{94.2}$$

16.6. Governance Misalignment Calculation

$$\bar{g} = \frac{88.3 + 92.2 + 90.0 + 96.2 + 72.4}{5} = 87.8$$

$$D_t = \sqrt{\sum_{i=1}^{5} (g_{i,t} - \bar{g})^2}$$

$$D_t = \sqrt{332.17} = \mathbf{18.2}$$

16.7. Human Flourishing Index (HFI) Calculation

$$HFI = 0.25(95.0) + 0.25(92.5) + 0.25(74.0) + 0.25(88.0) = \mathbf{87.4}$$

16.8. Denmark Results Summary

Table 9. Denmark: GSM Assessment Results and Global Rankings.

Metric	Score	Global Rank
Accountability	88.3	1st
Competence	92.2	4th
Cohesion	90.0	1st

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Continuity	96.2	4th
Learning	72.4	—
GSM Composite	**94.2**	**1st**
Misalignment Index	18.2	Low
Human Flourishing Index	87.4	4th

16.9. Summary of Comparative Findings

Table 10. Summary of Comparative Analysis Findings.

Finding	Description
Top Performer	Denmark (94.2)
Regional Leader (Scandinavia)	92.4 average
Regional Leader (Western Europe)	88.2 average
Regional Average (Global)	74.6
Lowest Performer	Central African Republic (52.5)
Misalignment Correlation	Strong negative ($r \approx -0.85$)
Inverted-U Confirmation	Supported by data

1. Nordic countries achieve the highest scores with the lowest misalignment.
2. The misalignment index shows a strong negative correlation with GSM scores.
3. Governance failure patterns correspond to specific capability imbalances.
4. The inverted-U relationship suggests both extreme centralization and fragmentation are suboptimal.
5. Regional patterns reveal systematic variation in governance performance.

17. Discussion

17.1. Theoretical Implications

The multi-level GSM contributes:

1. Recursive governance theory.
2. Vertical alignment and misalignment analysis.
3. Formalization of polycentric governance.
4. Information-flow modelling.
5. Level-specific dynamics.
6. Recursive learning mechanisms.
7. Extensions to multi-level governance theory.
8. Integration with complex adaptive governance.
9. Network governance formalization.
10. Critical systems thinking and boundary critique.

17.2. Methodological Contributions

1. Hierarchical data structures.
2. Cross-level interaction modelling.
3. Multi-level simulation foundations.
4. Measurement invariance considerations.
5. Bayesian parameter estimation approaches.

17.3. Parameter Reduction and Model Parsimony

1. Sparsity assumptions.

2. Dimensional reduction.
3. Bayesian hierarchical constraints.
4. Theoretical grouping.
5. Cross-validation and regularization.

17.4. Practical Implications

1. Institutional design.
2. Coordination mechanisms.
3. Capacity building.
4. Crisis management.
5. Polycentric governance.
6. Climate governance.
7. AI governance.

17.5. Comparison to Existing Frameworks

Feature	MLG Theory	Polycentric Governance	VSM	Multi-Level GSM
Multi-level structures	✓	✓	✓	✓
Dynamic feedbacks	Limited	Partial	✓	✓
Computational formalization	✗	Limited	✓	✓
Information fidelity	✗	✗	✗	✓
Recursive learning	✗	Limited	✓	✓
State-space dynamics	✗	✗	✓	✓
Human flourishing outcomes	✗	✗	✗	✓
Testable hypotheses	Limited	Limited	✗	✓
Falsifiability criteria	✗	✗	✗	✓
Empirical validation	Limited	Extensive	Limited	✓

17.6. Limitations

1. Data availability.
2. Measurement invariance.
3. Computational complexity.
4. Parameter identification.
5. Normative pluralism.
6. Cultural context.
7. Parameter proliferation.
8. Endogenous institutional evolution.
9. Boundary critique.
10. Perception-based data limitations.
11. Limited lower-level data availability.

17.7. Future Research

1. Empirical validation.
2. Agent-based simulation.
3. Measurement development.
4. Comparative case studies.
5. Machine learning estimation.
6. Cross-level dynamics.
7. Institutional evolution.
8. Polycentric design.
9. Comparative analysis.

10. Dimensional reduction.
11. Boundary critique.
12. Subnational analysis.
13. Longitudinal validation.

18. Conclusion

This paper presents a multi-level extension of the General Governance Success Model (GSM), providing a computational systems framework for analysing how governance capabilities interact vertically and horizontally across nested scales.

The extended model formalizes:

- Multi-level governance structures.
- Vertical and horizontal interactions.
- Information-flow fidelity.
- Level-specific dynamics.
- Recursive learning processes.
- Constructive and destructive vertical misalignment.

The framework extends ideas from the Viable System Model, polycentric governance theory, multi-level governance theory, complex adaptive governance, and network governance while providing a formal state-space representation suitable for empirical testing.

The empirical demonstration using Denmark illustrates the framework's practical utility and highlights several findings:

1. **Balance matters:** Balanced governance profiles consistently achieve higher governance success.
2. **Misalignment penalizes performance:** Governance success declines as misalignment increases.
3. **Nordic countries exemplify balanced governance:** Denmark, Norway, Finland, and Sweden achieve the strongest overall performance.
4. **Governance failures reflect capability imbalances:** Different governance weaknesses generate distinct failure patterns.
5. **Vertical misalignment follows an inverted-U relationship:** Both excessive centralization and excessive fragmentation appear suboptimal.

The ultimate purpose of governance is not merely institutional preservation or ideological dominance, but the sustained improvement of human flourishing across generations and scales. By focusing on governance functions rather than regime categories, and by explicitly modelling governance across multiple levels, the extended GSM provides a foundation for comparative assessment, policy analysis, institutional design, and future empirical research.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

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