Threshold Determinability and Parametric Compensation in Complex Systems

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Abstract. *This paper formulates and substantiates the Law of Threshold Determinability of the Whole and the theory of parametric compensation. The central proposition is: a set of elements is determinable as a unified whole if there exists a parameter configuration under which the determinability measure reaches the critical value Ψcrit. The theory is universal in scope and applicable to biological, social, economic, and informational systems. The paper examines the consequences of the law, regime dynamics, the cascading nature of interaction levels, and the mechanisms of parametric compensation as an instrument for preserving interaction levels.*
Keywords: threshold determinability, parametric compensation, interaction levels, aggregated representation, structural system dynamics.

0. Positioning of the Theory

This work constructs a theoretical framework describing the conditions for the emergence and preservation of interaction levels in systems composed of multiple elements. The central proposition is the Law of Threshold Determinability of the Whole, which links the existence of an interaction level to the attainment of a critical value of the set's determinability measure.

Scope of Applicability

The theory is universal in character and applicable to various classes of systems:

— biological — populations, flocks, ecosystems;
— social — groups, institutions, societies;
— economic — markets, production systems;
— informational — networks, cognitive structures.

Position Among Existing Approaches

The theory extends and generalizes a number of established research directions: theories of self-organization and complex systems, concepts of emergence, theories of multilevel systems, and models of adaptive and evolutionary processes. Unlike these approaches, the present work proposes a single formal criterion for the existence of a level and a mechanism for its preservation through parametric compensation.

Key Elements of the Theory

The theory rests on four foundational components:

— the threshold determinability function Ψ(S, O; θS, θO);
— the critical value Ψcrit;
— the aggregated representation of the set ES = A(S);
— the operator class OS acting on the set as a whole.

Core Mechanism

A system preserves an interaction level either through the development of parameters or through their redistribution — parametric compensation.

> *The theory describes a universal property of systems: the capacity of a set to become an object of interaction as a whole upon reaching threshold determinability, and to preserve that status through parameter redistribution.* **Threshold Determinability Theory (TDT).**

0.1. Relation to Existing Theories

The proposed framework is related to several established approaches in the study of complex systems, yet differs from them in its formal focus on threshold conditions for the existence of interaction levels.

Complex Adaptive Systems (Holland, Kauffman)

The theory is aligned with the tradition of Complex Adaptive Systems (Holland, 1992; Kauffman, 1993), where global structures emerge from local interactions. However, existing approaches primarily describe emergence qualitatively or through simulation, whereas the present theory introduces a formal threshold condition for the existence of a system-level interaction.

Field Theory (Bourdieu)

The concept of a structured field resonates with the work of Bourdieu (1984, 1993), where agents interact within relational spaces shaped by power and capital. In contrast, the present framework does not rely on symbolic or cultural constructs, defines the field through parametric determinability, and formalizes the conditions under which a field becomes an object of higher-level interaction.

Multilevel Selection (Sober and Wilson)

The hierarchical structure of levels is consistent with the multilevel selection theory proposed by Sober and Wilson (1998). However, while multilevel selection focuses on evolutionary dynamics of competing groups, the present theory introduces a general criterion for level formation independent of biological fitness and applicable to non-biological systems.

Synergetics (Haken)

The theory also relates to synergetics developed by Haken (1983, 2004), where macroscopic order emerges near instability points. The key distinction is that, instead of describing order formation near bifurcation points, the present work defines a threshold condition for when a system becomes a coherent object of interaction.

Key distinction. Existing theories explain how structures emerge. The present theory defines when a structure becomes actionable as a whole.

Contribution

The main contribution of the proposed framework is the introduction of: a threshold-based criterion of wholeness; a formal operator condition; and a mechanism of parametric compensation ensuring level persistence.

1. Problem Statement

We consider a set of elements:

$$S = \{s_1, s_2, \ldots, sN\}$$

and a class of operators O capable of interacting with S.

2. Parameter Space

Let the parameter spaces of the set and the operator be defined:

$$\Theta S,\ \Theta O$$

and the parameter domain:

$$R \subseteq \Theta S \times \Theta O$$

Each point (θS, θO) defines a specific system configuration.

3. Determinability Measure

We introduce the function:

$$\Psi(S, O; \theta S, \theta O)$$

which defines the degree to which the set S may be regarded as a unified whole with respect to operator O.

3.1. Axiomatic Properties of Ψ

To ensure mathematical rigor, we impose the following minimal axiomatic constraints on the function Ψ(S, O; θS, θO).

A1. Non-negativity

$$\Psi(S, O; \theta S, \theta O) \geq 0 \quad \text{for all } (\theta S, \theta O) \in R$$

A2. Monotonicity

Ψ is non-decreasing in the coherence parameter k, the set size N, and the communication density p; and non-increasing in the variability parameter σ:

$$\partial\Psi/\partial k \geq 0, \quad \partial\Psi/\partial N \geq 0, \quad \partial\Psi/\partial p \geq 0, \quad \partial\Psi/\partial\sigma \leq 0$$

A3. Boundary Conditions

Ψ vanishes when the set is empty or fully incoherent, and grows without bound as variability approaches zero:

$$\Psi = 0 \quad \text{when } N = 0 \text{ or } k = 0$$

$$\Psi \to \infty \quad \text{as } \sigma \to 0^+$$

A4. Continuity

Ψ is continuous in all parameters over the admissible domain R:

$$\Psi \in C^0(R)$$

A5. Separability

In the absence of coupling between set and operator parameters, Ψ decomposes into independent contributions:

$$\Psi(S, O; \theta S, \theta O) = f(\theta S) \cdot g(\theta O) \quad \text{when } \theta S \perp \theta O$$

Remark

These axioms are satisfied by all parametric forms used in the examples of Section 17, including the canonical form Ψ = (k · N · p) / σ. The axioms do not uniquely determine Ψ; they define the class of admissible determinability measures within the present framework.

4. Threshold Value

A critical value exists:

$$\Psi\text{crit}$$

5. Definition of Wholeness

The set S is determinable as a whole if there exists a parameter configuration (θS, θO) such that:

$$\Psi(S, O; \theta S, \theta O) \geq \Psi\text{crit}$$

6. Aggregated Representation

There exists a mapping:

$$A : S \rightarrow ES$$

where ES is the aggregated representation of the set S.

7. Proposition: Threshold Determinability

> ***Proposition 1.* Let Ψ satisfy axioms A1–A5, and let the aggregated representation A : S → ES exist. If there exists at least one parameter configuration (θS*, θO*) ∈ R such that Ψ(S, O; θS*, θO*) ≥ Ψcrit, then the class OS = {O : O(S) = O(ES)} is non-empty.**

Proof Sketch

(i) By assumption, there exists (θS*, θO*) such that Ψ(S, O; θS*, θO*) ≥ Ψcrit. By A4 (continuity), this condition holds on an open neighborhood U ⊆ R around (θS*, θO*).

(ii) By the existence of A (Section 6), the aggregated representation ES = A(S) is well-defined. We construct the operator O* via the projection:

$$O^*(S) := A^{-1}(\tilde{O}(ES))$$

where Õ is any operator acting on ES. By construction, O*(S) = O*(ES), so O* ∈ OS.

(iii) Therefore OS ≠ ∅. Since the construction holds for any Õ acting on ES, OS is generally non-singleton.

(iv) The converse (Section 10) follows directly: if Ψ < Ψcrit for all (θS, θO) ∈ R, then no configuration admits wholeness, the aggregated representation carries no interaction information, and OS = ∅. □

Note. *The existence and uniqueness of A are assumed here as a structural condition on the system. A full proof of existence under specific parametric families is left for subsequent work.*

8. Formal Statement

$$\exists(\theta S, \theta O) \in R: \ \Psi(S, O; \theta S, \theta O) \geq \Psi crit \implies \exists \ OS \neq \emptyset$$

9. Operator Criterion

$$\forall \ Oi \in OS: \ Oi(S) = Oi(ES)$$

That is, an operator acts on the aggregated representation of the set.

10. Converse Statement

$$\forall(\theta S, \theta O): \ \Psi(S, O; \theta S, \theta O) < \Psi crit \implies OS = \emptyset$$

11. Principle of Parametric Compensation

$$\Delta\theta_i < 0 \ \Rightarrow \ \exists j: \ \Delta\theta_j > 0$$

12. Regime Dynamics

12.1. Regime Preservation

$$\Psi \geq \Psi crit$$

The system preserves its current interaction structure.

12.2. Regime Loss

$$\Psi < \Psi crit$$

The system loses determinability and transitions to a new parameter configuration.

13. Level Cascade

If an operator reaches the determinability threshold:

$$\Psi(O, O'; \theta O, \theta O') \geq \Psi crit$$

then it enters the aggregated representation of the next level:

$$O \in E' \implies O \equiv S'$$

That is, the operator becomes the set of the next level.

14. Key Conclusion

The existence of at least one parameter configuration under which the set is determinable as a whole is a sufficient condition for the existence of an interaction level acting on that set as a whole.

15. Compact Form

$$\exists(\theta S, \theta O) : \Psi \geq \Psi crit \implies \exists\ OS \neq \emptyset,\ O(S) = O(ES)$$

16. Corollaries of the Law

Corollary 1. Condition for Level Existence

If

$$\exists(\theta S, \theta O) : \Psi(S, O; \theta S, \theta O) \geq \Psi crit$$

then

$$\exists\ OS \neq \emptyset$$

Interpretation: an interaction level exists if the set is reachable as a whole.

Corollary 2. Condition for Level Absence (symmetric)

If

$$\forall(\theta S, \theta O) : \Psi(S, O; \theta S, \theta O) < \Psi crit$$

then

$$OS = \emptyset$$

Interpretation: if the set never behaves as a whole, a super-level is impossible.

Corollary 3. Level Continuity (parametric compensation)

If the system is in regime $\Psi \geq \Psi$crit, small parameter changes may preserve the level through compensation:

$$\Delta\theta_i < 0 \Rightarrow \exists j : \Delta\theta_j > 0$$

Interpretation: the level does not vanish instantaneously — it is held by parameter balance.

Corollary 4. Threshold Character of Level Destruction

$$\Psi < \Psi crit \;\Rightarrow\; OS = \emptyset$$

Interpretation: the level disappears not gradually but at threshold crossing.

Corollary 5. Level Cascade

If for an operator the following holds:

$$\Psi(O, O'; \theta O, \theta O') \geq \Psi crit$$

then

$$O \in E' \;\Longrightarrow\; O \equiv S'$$

Interpretation: any level may become the basis for the next level.

Corollary 6. Level Boundedness

$$OS \neq \emptyset \;\Rightarrow\; \exists(\theta S, \theta O) : \; \Psi \geq \Psi crit$$

Interpretation: no level exists 'in itself' — only within the permissible parameter domain.

Corollary 7. Aggregated Action of the Operator

$$\forall \; Oi \in OS : \; Oi(S) = Oi(ES)$$

Interpretation: the level determines not only the existence of operators but also the form of their action.

Corollary 8. Relational Status of the Field

A change in the operator's parameters, with the set's parameters held constant, may lead to the disappearance of the interaction level:

$$\theta S = const, \;\; \theta O \rightarrow \theta O', \;\; \Psi(S, O; \theta S, \theta O') < \Psi crit \;\Longrightarrow\; OS = \emptyset$$

Interpretation: the field is a status of the set relative to a specific operator, not an intrinsic property of the set itself. The same object may constitute a field for one operator and not for another. The determinability function Ψ is defined jointly over the pair (θS, θO) — neither the set nor the operator alone determines the existence of an interaction level. This corollary is related to affordance theory (Gibson, 1979) and Umwelt theory (von Uexküll, 1909), where interaction potential is a property of the agent–environment pair rather than of either constituent alone.

17. Illustrative Examples

We consider a specific form of the function Ψ. Let the set of elements be:

$$S = \{s_1, s_2, \ldots, sN\}$$

where each element is characterized by two parameters:

— k — degree of coherence,
— σ — noise level.

17.1. Determinability Measure Model

Let the determinability measure of the set be defined by:

$$\Psi(S, O; \theta S, \theta O) = (k \cdot N) \;/\; \sigma$$

with the threshold:

$$\Psi crit = C$$

17.2. Example 1. Formation of a Whole

Let:

$$k = 0.2, \quad \sigma = 1.0, \quad \Psi crit = 1.0$$

Then:

$$\Psi = 0.2 \cdot N$$

Determinability condition:

$$0.2N \geq 1.0 \;\Rightarrow\; N \geq 5$$

Conclusion: at N ≥ 5 the set becomes determinable as a whole. Therefore:

$$\exists(\theta S, \theta O) : \;\Psi \geq \Psi crit \;\Rightarrow\; \exists\, OS \neq \emptyset$$

17.3. Example 2. Level Loss under Increasing Noise

Let:

$$N = 10, \quad k = 0.2, \quad \sigma = 3.0$$

Then:

$$\Psi = (0.2 \cdot 10) \;/\; 3 \approx 0.67 < 1.0$$

Conclusion: the threshold is violated:

$$\Psi < \Psi crit \;\Rightarrow\; OS = \emptyset$$

The interaction level is absent.

17.4. Example 3. Level Cascade

Consider operator O which itself forms a set of operators O′ with the following parameters:

$$kO = 0.5,\ \ \sigma O = 1.0,\ \ NO = 3$$

Then:

$$\Psi(O, O'; \theta O, \theta O') = (0.5 \cdot 3) / 1.0 = 1.5 \geq 1.0$$

Conclusion: the operator reaches the determinability threshold Ψ(O,O′) ≥ Ψcrit and, according to the level cascade law:

$$O \in E' \ \Rightarrow\ O \equiv S'$$

That is, the operator becomes the set of the next level.

18. The Natural System as a Prototype of Structural Dynamics

As an illustration of the universality of the Law of Threshold Determinability, we consider a natural system possessing all the key properties of a social structure, yet devoid of cultural, institutional, and symbolic factors. This allows us to isolate the purely parametric basis of interaction and to demonstrate that the law operates independently of the level of cognitive complexity of the elements.

Consider the set:

$$S = \{s_1, s_2, \ldots, sN\}$$

where elements s_i are individuals of a biological community (e.g., a population of herbivores). Each individual is characterized by the parameters:

— k — degree of behavioral coherence (movement synchrony, signal-following),
— σ — variability of individual responses,
— p — density and availability of communication,
— N — group size.

18.1. Determinability Measure of a Biological Set

Let the determinability measure be defined by:

$$\Psi = (k \cdot N \cdot p) / \sigma$$

This function reflects the capacity of the set to function as a unified whole: high coherence k strengthens collective behavior; growing N creates a mass effect; dense communication p ensures signal propagation; high variability σ reduces coherence.

18.2. Threshold Behavior

The set becomes determinable as a whole when $\Psi \geq \Psi crit$. Observed manifestations: herds of herbivores move as a unified whole at sufficient density and coherence; flocks of birds form coherent structures at high signal-propagation speed; insect colonies act as a unified system at low behavioral variability.

When the threshold is violated — $\Psi < \Psi crit$ — fragmentation into subgroups, loss of movement coherence, and reduced capacity for collective action are observed.

18.3. Level Hierarchy: Resource → Field → Operator

The natural system exhibits a sequential level structure analogous to the social one.

(1) Resource level (vegetation)

Vegetation forms the distributed set Sgrass. If its distribution satisfies $\Psi(Sgrass, Oherb) \geq \Psi crit$, it becomes the field for herbivores.

(2) Herbivore field

Herbivores form the set Sherb, which upon reaching the threshold becomes determinable as a whole:

$$\Psi(\mathrm{Sherb}) \geq \Psi\mathrm{crit}$$

(3) Operator level (predators)

The predator acts as operator Opred and interacts with the herd as an aggregated whole when $\Psi(Sherb, Opred) \geq \Psi crit$. The herd becomes the field; the predator interacts with it not as with individual specimens, but as with a unified structure.

18.4. Parametric Compensation

Natural systems exhibit the compensation principle (Corollary 3): a decrease in coherence k is compensated by an increase in communication density p; a rise in noise σ is compensated by an increase in group size N; a reduction in communication is compensated by stronger local following.

$$\Delta\theta_i < 0 \;\Rightarrow\; \exists j: \; \Delta\theta_j > 0$$

18.5. Operator Constraints

If the field parameters fall below the threshold:

$$\Psi < \Psi\mathrm{crit} \;\Rightarrow\; \mathrm{Opred} \notin \mathrm{OS}$$

The predator can no longer effectively interact with the fragmented group as a whole; interaction becomes local and less efficient.

18.6. Dynamics and Evolutionary Selection

Natural systems exhibit sustained parameter dynamics. Transition through the threshold $\Psi \approx \Psi crit$ leads to intensified selection of behavioral strategies and consolidation of configurations capable of sustaining wholeness. Natural selection may be regarded as a mechanism of parameter redistribution in the system near threshold states.

18.7. Key Conclusion

> **Natural systems exhibit all structural properties of the Law of Threshold Determinability: threshold behavior, parametric compensation, level hierarchy, and transition dynamics. This demonstrates that the law describes universal mechanisms of set organization, independent of cultural or institutional factors.**

19. From the Biological to the Social: Structural Invariance

The transition from biological to social systems does not alter the structure of the law — only the substantive interpretation of the parameters changes. In social systems, k encompasses institutional coherence, normative uniformity, and ideological synchronization; σ covers cultural variability, multiplicity of interpretations, and actor autonomy; p describes communication networks, institutions, markets, and media environments; N is determined not merely by headcount but by the effective engagement of elements.

The defining distinction of social systems lies in the reflexivity of operators: in such systems, purposive action on the parameters of the field is observed, aimed at maintaining Ψ near the threshold. This reflexivity transforms parametric compensation from an adaptive mechanism into a stable management configuration — which is the subject of the following section.

19.1. Multilevel Structure of a Social System

A social system possesses a multilevel structure in which each level is defined by its own value of the threshold function Ψ and its own class of operators. Formally:

$$S^{(0)} \rightarrow S^{(1)} \rightarrow S^{(2)} \rightarrow \ldots$$

where $S^{(0)}$ is the base level of elements; $S^{(1)}$ is the aggregated set; $S^{(2)}$ is the operator level; and so forth.

Key Property

Each level may serve as the set for the next, provided the threshold determinability condition is satisfied:

$$\Psi(S^{(i)}, O^{(i)}) \geq \Psi crit$$

Corollary

System governance may operate simultaneously at different levels, and parameter changes at one level may compensate or amplify changes at another. In interpretive terms: individuals → groups → institutions → supra-institutional structures; local processes → systemic effects; micro → meso → macro.

20. Development Constraint and Parameter Substitution (Sociological Application)

We consider a situation in which an operator interacts with the set S in a regime of sustained threshold excess:

$$\Psi \geq \Psi crit$$

Under such conditions, a configuration is observed in which parameters are maintained at a level ensuring the preservation of the current composition of class OS.

20.1. Two Mechanisms for Threshold Maintenance

Two fundamentally distinct mechanisms for preserving the value of Ψ exist:

(A) Endogenous development

Parameter growth through internal restructuring of the set:

$$k\uparrow,\ \ \eta\uparrow,\ \ p\uparrow$$

(B) Parametric compensation

Preservation of Ψ through parameter redistribution:

$$\eta\downarrow\ \Rightarrow\ \exists\{N\uparrow,\ \sigma\downarrow,\ p\downarrow,\ k\uparrow\}$$

20.2. Constraint on Endogenous Development

Endogenous development is accompanied by:

— growth in variability σ,
— increasing complexity of connections p,
— redistribution of roles,
— rising efficiency η.

These processes alter the structure of the set and may lead to a change in the threshold:

$$\Psi crit\ \mapsto\ \Psi crit'$$

Corollary: growth in internal system complexity may lead to a change in the operator level.

20.3. Regime Selection

If the development of the set leads to a change in the composition of admissible operators, a stable persistence of the compensatory regime without realization of endogenous development is observed.

20.4. Structure of the Compensatory Regime

In the compensatory regime, the following parameter changes are observed:

1. Resource concentration

$$N_{eff}\uparrow, \quad k_{local}\uparrow$$

(local high organization under overall heterogeneity).

2. Variability reduction

$$\sigma\downarrow$$

(restriction of diversity of states and interpretations).

3. Communication restriction

$$p\downarrow$$

(reduction of horizontal connectivity among elements).

4. Efficiency redistribution

$$\eta_{global}\downarrow, \quad \eta_{local}\uparrow$$

(targeted projects under overall declining system efficiency).

20.5. Utilization of Accumulated Resources

The system may sustain the compensatory regime by drawing on accumulated resources:

$$R_{stock}\downarrow$$

Including: infrastructure, accumulated knowledge, institutional structures.

20.6. Constraint on Parameter Reproduction

Under prolonged compensatory regime:

$$d\eta/dt < 0, \quad dR_{stock}/dt < 0$$

That is, the efficiency and resilience reserve of the system decline.

20.7. Demographic Compensation

Under declining element efficiency:

$$\eta\downarrow \Rightarrow N\uparrow$$

(attempt to compensate for efficiency decline through increased element count).

20.8. Mobility and Connectivity Restriction

$$p\downarrow$$

(reduction of horizontal linkages and mobility of set elements).

20.9. Variability Management

$$\sigma\downarrow$$

(reduction in diversity of interpretations and alternative structures).

20.10. Coherence Reinforcement

$$k\uparrow$$

(through external synchronization mechanisms and enforced coordination).

20.11. External Environment Transformation

When internal parameter restoration is not achievable, an attempt at altering the configuration of the external interaction environment is observed:

$$pext \rightarrow \tilde{p}ext$$

(reconfiguration of interaction with external fields).

20.12. Development Constraint as a Stable Regime

In certain system configurations, the following dynamics are observed. Endogenous development leads to:

— growth in η,
— increase in σ,
— strengthening of p,
— decline in element dependence on the operator.

This alters the determinability conditions of the set as a whole and may lead to operator turnover.

20.12.1. Observed Parameter Configuration

In such cases, the system may:

— maintain parameters through compensation,
— concentrate resources in local structures,
— restrict variability and connectivity,
— redistribute resources from reproductive subsystems,
— reduce element autonomy,
— draw on accumulated resources,
— restrict alternative forms of organization.

20.13. Key Conclusion

> **A system is capable of sustaining threshold determinability over extended periods not through endogenous development, but through parameter redistribution from reproductive subsystems. This regime is accompanied by declining parameter reproducibility, growing dependence on external coordination, and accumulation of structural instability.**

20.14. Technology Stagnation as a Stable Parameter Configuration

Under a sustained compensatory regime, a structural contradiction emerges. Technological development — requiring qualitative changes in the field, including growth of element autonomy, strengthening of horizontal linkages, and diversification of knowledge sources — has a high probability of shifting the determinability threshold:

$$\Psi\text{crit} \mapsto \Psi\text{crit}' > \Psi\text{crit}$$

This means that under the new parameter configuration, the current operator may fall below the threshold:

$$\Psi(S, O; \theta S, \theta O) < \Psi\text{crit}' \Rightarrow O \notin OS'$$

Consequently, endogenous technological development carries the risk of level change — alteration of the composition of class OS. As a result, a configuration is observed in which endogenous development is not realized, and parameters are maintained through targeted resource concentration.

20.15. Targeted Projects as an Instrument of Local Parameter Concentration

In the absence of systemic parameter growth in η and k, their local concentration is observed: field resources are redistributed into a limited number of managed structures:

$$N_{eff,local}\uparrow,\quad k_{local}\uparrow,\quad R_{global}\downarrow$$

Such projects create local threshold excess without altering the overall field structure. The aggregated field representation for the operator remains unchanged, while global parameters continue to degrade.

20.16. Inter-Field Conflict as a Configuration Change Mechanism

If interaction with adjacent fields does not yield configuration change through institutional mechanisms, a transition to externalization of parametric pressure is observed:

$$p_{ext} \rightarrow \tilde{p}_{ext} \quad (\text{via non-institutional mechanism})$$

A specific case of such externalization is the non-institutional reconfiguration of external interaction, involving the redistribution of the human resource of the field toward changing the external configuration. The expected consequence is the formation of a new environmental configuration under which field parameters return above the threshold:

$$R_{field}\downarrow \;+\; N_{human}\downarrow \;\rightarrow\; \tilde{p}_{ext} \;\rightarrow\; \Psi(S, O; \tilde{\theta}_S, \tilde{\theta}_O) \geq \Psi_{crit}$$

The new field configuration is formed in the interests of the same class OS, as the conditions of the new field are defined by the same operators.

20.17. Degradation of Reproductive Infrastructure

Under a sustained extraction regime, sequential redistribution of the field's accumulated resource from reproductive subsystems is observed. Formally, this is the reproducibility reserve:

$$R_{repro} = \{R_{health},\ R_{edu},\ R_{infra},\ R_{inst}, \ldots\}$$

Each element of R_{repro} possesses an accumulation property: it was formed in a preceding period and sustains field viability in the absence of new investment. As the return of resources to reproductive subsystems decreases, it is temporarily released for other purposes:

$$dR_{repro}/dt < 0 \quad \text{when} \quad R_{extract} > R_{return}$$

The long-term consequence is a decline in field viability and a reduced capacity to reproduce parameters k, η, p at prior levels.

20.18. Management of the Field's Information Environment

In the field's information environment, a decline in horizontal communication (p↓) is observed, along with restriction of alternative interpretation accumulation and substitution of open knowledge sources with templated narratives. Formally:

$$\sigma info\downarrow, \quad p\downarrow, \quad \tilde{k}\uparrow \quad \text{(via external synchronization)}$$

Here $\tilde{k}$ denotes coherence induced by external coordination , as distinct from k — coherence arising from internal self-organization of the field. These two forms of coherence differ fundamentally in stability : $\tilde{k}$ requires continuous maintenance and degrades when information control is weakened.

20.19. Demographic Adjustments as Compensation for Efficiency Decline

Under sustained decline in element efficiency (η↓), compensation through increased active element count and utilization intensity is observed:

$$\eta\downarrow \ \Rightarrow \ N\uparrow \quad \text{(fertility incentives, emigration restriction)}$$

$$GDP \approx \eta \cdot N \cdot h, \quad \eta\downarrow \ \Rightarrow \ \{N\uparrow \ \text{or} \ h\uparrow\}$$

where h is the utilization intensity of elements (working hours, retirement age). This parameter configuration does not eliminate the cause of η decline but merely compensates its effect temporarily.

20.20. Mobility Restriction as a Parameter Lock

High-mobility elements typically possess elevated values of η and k, making their departure disproportionately damaging to the aggregate field parameters:

$$\Delta\eta\_field = -(\eta\_i - \bar{\eta}) \cdot \Delta N\_out \quad (\text{when } \ \eta\_i > \bar{\eta})$$

Mobility restrictions — administrative, legal, and economic — are introduced, preventing the departure of the most valuable elements. A 'parameter lock' is formed: the field is held in a configuration sufficient to exceed the threshold by constraining the composition and size of the set.

20.21. Coercive Suppression of Internal Variability

Horizontal communication among field elements can generate self-organization and new configurations potentially driving the system beyond the current threshold regime. Suppression of this dynamic is observed through the following mechanisms:

— restriction of the right to assembly and public expression of coordinated positions (p↓),
— criminal prosecution of carriers of alternative interpretations (σ↓ enforced),
— strengthening of enforcement structures as an instrument for maintaining $\tilde{k}$ through fear,
— construction of the perception of isolation among dissenting elements.

Formally, the resulting configuration minimizes the probability that an alternative operator O′ reaches the threshold:

$$\Psi(S, O'; \theta S, \theta O') < \Psi crit \quad \forall \ O' \neq O$$

21. Empirical Case: A High-Rent-Component System in a Parameter Retention Regime

The case examined here represents a typical parameter configuration observed in a number of systems with a high rent component, and is presented for illustrative purposes. The dynamics described above — absence of endogenous technological development, targeted resource concentration, externalization of parametric pressure, redistribution of resources from reproductive subsystems, and suppression of internal variability — are treated as one of the possible parameter configurations admitted by the model.

21.1. Initial Configuration: Rent Model and Technology Stagnation

The initial state is characterized by: low value-added production ($\eta\_prod\downarrow$), a high share of primary resource exports, and weak competitiveness in knowledge-intensive markets. With sufficient rent income, no structural incentive for developing the field's technological potential is formed:

$$\Psi \geq \Psi crit \quad \text{with} \quad \eta\_prod\downarrow, \;\; Rresource = const$$

A configuration is observed in which endogenous technological development is not realized, as it would potentially alter $\Psi crit$ and the composition of admissible operators.

21.2. Targeted State Projects

Under growing deficit of parameter η, large-scale resource accumulation in managed state structures is observed — local concentration of N and R while preserving the overall field configuration:

$$Neff,local\uparrow, \;\; klocal\uparrow, \;\; \eta global = const \;\; \text{or} \;\; \downarrow$$

The effectiveness of such projects is limited by the absence of systemic parameter change in the field — they generate localized activity surges that do not reproduce autonomously.

21.3. External Market Barriers and the Transition to Externalization

Attempts at integration into global production chains encounter structural barriers from adjacent fields. Institutional resolution mechanisms do not yield the desired reconfiguration of the external environment. A transition to the non-institutional mechanism of external configuration change is observed:

$$R\_coercive > 0, \;\; p\_inst\_ext \to 0 \;\Rightarrow\; \text{non-institutional mechanism of external configuration change}$$

The non-institutional configuration change is accompanied by redistribution of the field's human resource (Nhuman↓). The expected consequence is the formation of a new external configuration. The new field configuration is formed in the interests of the same class OS.

21.4. Cascade of Parametric Adjustments under Conflict Conditions

Non-institutional external configuration change triggers cascading parameter degradation in the field, generating the simultaneous application of multiple compensating mechanisms:

— increased tax burden — accelerated depletion of Rfield,
— forced mobilization — N_civilian↓,
— emigration restrictions — parameter lock,
— intensification of information control — σ↓, p↓,
— fertility incentives — long-term compensation for N↓,
— raising retirement age and working hours norm — h↑,
— strengthening of enforcement apparatus — enforced k̃.

The system is in a regime of simultaneous application of all mechanisms under escalating degradation of the reproductive resource:

$$\partial\Psi/\partial t \approx 0 \quad \text{with} \quad dRrepro/dt \ll 0$$

21.5. Cognitive Management and Legitimation

Simultaneously, the formation of a managed cognitive environment of the field is observed: substitution of open knowledge sources with templated narratives, restriction of access to alternative interpretations. In sociological terms, this corresponds to legitimation through symbolic violence or agenda-setting. In model terms:

$$\sigma\_cogn\downarrow, \;\; \tilde{k}\uparrow, \;\; p\_horizontal\downarrow$$

Effect: the probability that alternative operators O′ reach the determinability threshold decreases, as field elements do not form stable coherence around alternative configurations.

21.6. Key Conclusion of the Empirical Case

> **The examined case demonstrates that a system with a high rent component in a parameter retention regime reproduces a stable configuration: endogenous field development is not realized, parametric pressure is externalized through non-institutional mechanisms, resources are redistributed from reproductive subsystems, and the cognitive field environment is managed through reductions in σ and p. Threshold determinability is sustained through the simultaneous application of multiple compensating mechanisms, each of which accelerates the degradation of the resource on**

which it is based. Structural instability accumulates, raising the probability of a phase transition upon exhaustion of the compensatory reserve.

21.7. Falsifiability Conditions

The empirical case presented in Section 21 generates testable predictions. The compensation hypothesis is falsified if any of the following conditions are observed in a high-rent-component system:

— η rises simultaneously with $\tilde{k}$ — this would indicate that induced coherence and genuine development co-occur, contradicting the structural contradiction of Section 20.14.

— σ and p increase over time while Ψ remains above threshold — this would mean the system sustains wholeness through endogenous development, not compensation.

— Rrepro recovers after a period of extraction without external input — this would falsify the monotonic depletion model of Section 20.17.

— Nhuman↓ does not correlate with external configuration change — this would disconnect the mechanism of Section 21.3 from its predicted parameter trajectory.

More broadly, the TDT framework is falsified at the level of the general law if a system is observed in which: (a) $\Psi \geq \Psi crit$ is satisfied, yet $OS = \emptyset$ — no operator class acts on S as a whole; or (b) $OS \neq \emptyset$ persists indefinitely despite $\Psi < \Psi crit$ across all accessible configurations.

Operationalization of these conditions for empirical research would require time-series measurements of proxy variables for η (labor productivity, TFP), σ (media pluralism indices, political diversity scores), p (network connectivity, migration rates), and N (effective workforce participation). Such a research program lies beyond the scope of the present theoretical paper but defines its empirical extension.

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Catastrophe Theory (Thom, 1972; Arnold, 1984) — The convergence lies in the threshold-like nature of the transitions; the distinction is that TDT introduces a criterion for the existence of a level—along with a mechanism for its maintenance—rather than the geometry of singular points.