On the Ontic Symmetry of Concepts and Their Generation through Symmetry-Breaking

A Preliminary Cross-Disciplinary Discussion

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Abstract

We propose and preliminarily articulate a concept we term the *Ontic Symmetry of Concepts*: the thesis that core concepts across distinct scientific and philosophical domains share a common underlying structural symmetry at the ontic level, and that the apparent diversity of domain-specific concepts arises through *symmetry-breaking* of this underlying structure. The view advanced here makes three claims. *First*, that such symmetries are real (an ontological claim) rather than mere notational coincidences or analogical artifacts. *Second*, that they are epistemically accessible through formal-mathematical structures, and that their identification can be operationalized. *Third*, that this view yields a productive research programme: it reframes the apparent "unreasonable effectiveness" of cross-disciplinary mathematical analogy not as miraculous coincidence but as the trace of a generative ontology. We sketch operational tools—group theory, field theory, and dynamical systems theory—through which such symmetries can be made tractable, and discuss illustrative cases including the structural correspondence between Pareto optimality and dynamical equilibrium points, and between the marginal state in economics and the fiber bundle in differential geometry. The paper is preliminary in scope: it aims to define the concept, argue for its existence and knowability, and indicate paths for further inquiry.

Keywords: ontic symmetry; symmetry-breaking; generativity; cross-disciplinary isomorphism; relational ontology; philosophy of science; group theory.

1 Introduction

1.1 The phenomenon

Across the sciences, one repeatedly encounters the same formal structure under different names. The Pareto-optimal frontier in welfare economics is, in its mathematical structure, a stratified manifold of equilibrium points familiar from dynamical systems theory. The notion of marginal change in economics is, structurally, a section of a cotangent bundle. The Boltzmann entropy of statistical mechanics, the Shannon entropy of information theory, and the Rényi entropy

of statistics all share the same functional form. Phase transitions in physics, tipping points in ecology, and bifurcations in dynamical systems are not analogies but, on closer inspection, specializations of a single mathematical object.

Such recurrences are widely noted but seldom theorized at a properly ontological depth. They are typically framed in one of three ways: as the *unreasonable effectiveness of mathematics* [Wigner, 1960], as a feature of human conceptual schemes (a Kantian reading), or as a consequence of evolutionary or pragmatic convergence on tools that work. Each of these explanations has merit; none, we argue, is fully adequate to the phenomenon.

1.2 Thesis

This paper proposes and preliminarily defends a fourth account, which we call the thesis of the *Ontic Symmetry of Concepts*. The thesis comprises two coupled claims:

Claim 1 (Ontic Concept-Symmetry)**.** *Core concepts across distinct domains share a real, mind-independent structural symmetry at the ontic level. The mathematical isomorphisms observed between, e.g., Pareto optimality and dynamical equilibrium are not artifacts of representation but are traces of a deeper structural identity in being.*

Claim 2 (Generative Symmetry-Breaking)**.** *Domain-specific concepts are themselves generated through the breaking of an underlying symmetry. The diversity of conceptual vocabularies across the sciences is not a primitive datum but the* outcome *of a generative process whose mechanism is symmetry-breaking.*

The combination of these two claims yields a position we may summarize as: *conceptual diversity is the broken image of an underlying ontic unity.*

1.3 Aims of this paper

This is a preliminary paper. Its aims are correspondingly modest:

1. To **define** the concept of Ontic Concept-Symmetry with sufficient precision to distinguish it from neighboring positions (mathematical Platonism, structural realism, conceptual analogy theory).
2. To **argue** for both its ontological existence and its epistemic accessibility.
3. To **sketch** operational tools—group theory, field theory, dynamical systems theory—through which the thesis can be developed into a working research programme.
4. To **illustrate** the thesis with case studies drawn from economics, physics, and the formal sciences.

We do not claim to settle the deep metaphysical questions our thesis raises. We claim only that the thesis is well-formed, defensible, and productive of further inquiry.

1.4 Plan

Section 2 defines the concept. Section 3 surveys the phenomena that motivate it and addresses the existence, knowability, and practicability of ontic concept-symmetry. Section 4 develops the epistemology—how such symmetries are to be recognized. Section 5 sketches operational tools. Section 6 presents case studies. Section 7 discusses limitations, alternatives, and connections to related work. Section 8 concludes.

2 Definition of the Concept

2.1 Ontic Concept-Symmetry

We begin with a working definition.

Definition 1 (Ontic Concept-Symmetry, working definition)**.** *Let $D_1, D_2, \ldots, D_n$ denote distinct domains of inquiry (e.g., physics, economics, ecology, semantics). Let $C_i \subseteq D_i$ denote a core concept of domain D_i. We say that the concepts $\{C_1, \ldots, C_n\}$ exhibit* ontic concept-symmetry *if there exists a structure Σ, characterizable in mathematical terms, such that each C_i is a representation (in the technical sense) of Σ within the descriptive vocabulary of D_i, and such that the obtaining of this representation is not a feature of our schemes of description but of the entities themselves.*

The key word is *representation in the technical sense*: each C_i is not merely *like* Σ but *is* a realization of Σ in the sense familiar from the representation theory of groups and the theory of natural transformations between functors.

2.2 Generative Symmetry-Breaking

Definition 2 (Generative Symmetry-Breaking)**.** *Given an underlying symmetric structure Σ with symmetry group G, we say that a domain-specific concept C_i* arises through symmetry-breaking *if C_i is the realization of Σ under conditions that break the full symmetry G down to a subgroup $H_i \subset G$. The diversity of $\{C_1, \ldots, C_n\}$ is then the consequence of the diversity of breaking patterns $\{H_1, \ldots, H_n\}$.*

This is the move that distinguishes our thesis from a purely static structural realism. We are not claiming that there is a fixed structure Σ which all sciences happen to describe; we are claiming that Σ is generative—that domain-specific concepts *come into being* through specific patterns of symmetry-breaking.

2.3 Distinction from neighboring positions

It is important to distinguish our thesis from positions with which it might be confused.

From Platonism. Mathematical Platonism holds that mathematical objects exist independently of human thought. Our thesis is compatible with but does not require Platonism. The structure Σ in our account need not be a Platonic object; it may be understood as a feature

of physical or relational reality. What our thesis shares with Platonism is a commitment to the mind-independence of structural facts; what it adds is an account of how diverse concepts *generate* from such structure.

From Ontic Structural Realism. Ladyman & Ross [2007] and others have argued that all there is, fundamentally, is structure. Our thesis is closer to OSR than to Platonism, but differs in two respects. *First*, OSR is typically a thesis about physics; our thesis is explicitly cross-disciplinary. *Second*, OSR has historically said little about generativity; our thesis foregrounds the breaking of symmetry as the mechanism of conceptual diversity.

From conceptual analogy. Theories of cross-disciplinary analogy [Hesse, 1966] treat structural similarity as a feature of representations. Our thesis treats structural similarity as a feature of being, of which representations are traces. The difference is ontological, not merely terminological.

3 Phenomena: Existence, Knowability, Practicability

In this section we survey the recurring phenomena that motivate the thesis, and we address three questions in turn: whether ontic concept-symmetry exists, whether it can be known, and whether it can be operationalized in practice.

3.1 The phenomena to be explained

We list, without yet developing them in detail, several cross-disciplinary correspondences that motivate the thesis. Each is a case in which a single mathematical structure surfaces independently in two or more distinct domains.

1. **Equilibrium**. Pareto optimality in welfare economics, Nash equilibrium in game theory, thermodynamic equilibrium in physics, evolutionarily stable strategies in biology, and fixed points of dynamical systems all share the structure of a critical point on a manifold of states—specifically, a point at which a certain variation operator vanishes.

2. **Entropy**. The Boltzmann entropy of statistical mechanics, the Shannon entropy of information theory, and the family of Rényi entropies of statistics share the functional form $H = -\sum p_i \log p_i$ (or its generalizations); the same object appears as the von Neumann entropy in quantum mechanics and as the topological entropy in dynamical systems.

3. **Marginal change**. The economic concept of marginal utility, marginal cost, and marginal product is structurally a directional derivative on a manifold of states—a section of a cotangent bundle. The same structure underlies infinitesimal generators in physics and gradient descent in machine learning.

4. **Phase transition**. Critical phenomena in condensed matter physics, tipping points in ecological systems, regime shifts in macroeconomics, and bifurcations in dynamical systems share the structure of a singular change in qualitative behavior at a critical value of a control parameter.

5. **Symmetry breaking**. The Higgs mechanism in particle physics, magnetization in ferromagnets, the formation of biological patterns à la Turing [Turing, 1952], and the differentiation of cells from a totipotent precursor all share the structure of a transition from a more symmetric state to a less symmetric one.

These cases are not merely analogous; in each, the underlying mathematical structure is identical. We claim that the explanation of this phenomenon is the existence of an underlying ontic structure of which each domain-specific concept is a representation.

3.2 The argument for existence

The argument for the ontological existence of concept-symmetry rests on an inference to the best explanation. The candidate explanations are:

1. **Coincidence**: The recurrences are accidents of mathematical notation.
2. **Cognitive constraint**: The recurrences reflect features of human cognition (Kant) or of the linguistic schemes we happen to have inherited.
3. **Pragmatic convergence**: Sciences converge on similar structures because similar problems require similar tools.
4. **Ontic concept-symmetry**: The recurrences reflect a real structural identity at the level of being.

We argue against (1) on grounds of frequency and depth. The recurrences are too numerous, too mathematically deep, and too predictively fertile to be coincidental. The structural identity of, say, the Higgs mechanism and Turing pattern formation is not merely formal; it predicts behavior in one domain on the basis of analysis in another.

We argue against (2) on grounds of unification. Cognitive-constraint accounts can explain why *we* see structural similarity across domains; they do not explain why the similarity *predicts new empirical facts*. Predictive success is a mark of mind-independence, not of cognitive projection.

We argue against (3) on grounds of explanatory depth. Pragmatic convergence explains why we use similar tools; it does not explain why the underlying structures these tools track are themselves similar. The pragmatic explanation begs the question by presupposing the very recurrence it is meant to explain.

This leaves (4) as the best available explanation. We acknowledge that this argument is non-demonstrative and that it does not establish the precise ontological status of the underlying Σ. We claim only that the existence of *some* mind-independent structural fact is the most economical explanation of the phenomena surveyed.

3.3 The argument for knowability

The thesis would be of limited interest if the ontic symmetry it posited were inaccessible to human inquiry. We argue that it is not.

The means of access is mathematical formalization. When we identify a recurring structure across domains, we do so by abstracting away from domain-specific vocabulary and identifying the structural invariants that survive translation. The languages best suited to this task are those that have been developed precisely to make symmetry tractable: group theory, representation theory, category theory, and (more recently) the formal apparatus of homotopy type theory and higher categories.

The epistemic warrant for a claim of ontic concept-symmetry is, on our account, a triple criterion:

1. **Mathematical isomorphism**: The structures in the relevant domains can be exhibited as isomorphic in a precisely specified mathematical sense.

2. **Predictive transfer**: Insights derived in one domain transfer to the other, generating novel testable predictions.

3. **Generative coherence**: The symmetry-breaking pattern that distinguishes the two domains is itself characterizable, and the resulting concept-divergence is intelligible as a consequence of this pattern.

A claim of ontic concept-symmetry is well-founded only when all three conditions are met. Mere mathematical isomorphism, without predictive transfer, may be coincidence. Mathematical isomorphism with predictive transfer but without intelligible breaking-pattern may indicate a more superficial structural identity. The full thesis requires all three.

3.4 The argument for practicability

To the practical scientist, an ontological thesis is of value only insofar as it guides inquiry. We argue that our thesis does so guide.

The thesis prescribes a research strategy: *when a concept in one domain resists analysis, look for its symmetry-counterpart in another domain.* If marginal analysis in economics is structurally the cotangent bundle of differential geometry, then results from differential geometry are directly applicable to economic problems—and conversely. If Pareto optimality is a stratified manifold of dynamical equilibria, then the bifurcation theory of dynamical systems is directly applicable to questions of welfare economics.

This strategy has been pursued, often without explicit theoretical articulation, in fields ranging from mathematical economics to mathematical biology to physical chemistry. Our thesis offers a unified philosophical foundation for what is, in practice, already a productive research strategy.

4 The Epistemology of Ontic Concept-Symmetry

We now turn to the epistemological question: how are ontic concept-symmetries to be recognized, distinguished from spurious analogies, and rigorously characterized?

4.1 Recognition criteria

The triple criterion sketched above (mathematical isomorphism, predictive transfer, generative coherence) provides a procedural answer. We elaborate on each.

Mathematical isomorphism. Two concepts C_1 and C_2 in domains D_1 and D_2 exhibit mathematical isomorphism if there exist mathematical structures M_1 and M_2 such that C_i is faithfully represented by M_i, and there is an isomorphism $f : M_1 \to M_2$ in an appropriately rich category. "Appropriately rich" is here a placeholder for further analysis; it is critical that the isomorphism preserve the structure relevant to the explanatory work the concept does in its domain.

Predictive transfer. An isomorphism is epistemically robust if results derivable in one structure transfer to the other, yielding predictions in the receiving domain that would not otherwise be available. This is the empirical check on the claim of structural identity.

Generative coherence. The isomorphism, supplemented with an account of the symmetry-breaking pattern that distinguishes the two domains, must yield an intelligible account of why the two concepts *differ* despite their underlying identity. This is the constructive check.

4.2 Mathematical formalization as epistemic warrant

Why should mathematical formalization play this central epistemic role? The answer is not arbitrary. Mathematics, particularly in its modern form, has developed precisely as the language in which structural facts can be expressed without commitment to particular interpretive frameworks. Group theory, in identifying the symmetries of a structure, abstracts from any particular instantiation of that structure. Category theory, in identifying objects only up to isomorphism, foregrounds structural identity over surface description.

If our thesis is correct, then these mathematical languages are not merely *useful tools* for cross-disciplinary work; they are the most direct linguistic access we have to the ontic structure that grounds the recurrences they capture. This is a strong claim, but it is consonant with positions in the philosophy of mathematics that have argued, in different ways, for the structural depth of mathematics [Shapiro, 1997, Awodey, 2004].

4.3 The role of failure: when symmetry-claims break down

Not every alleged cross-disciplinary correspondence is a genuine ontic concept-symmetry. Some are mere notational coincidences; others are structural similarities at one level that fail to extend. The epistemology of ontic concept-symmetry must therefore include an account of failure.

A symmetry-claim fails when one of the three criteria is violated. It is illuminating to examine cases of apparent failure: the alleged isomorphism between economic equilibria and physical equilibria, for example, breaks down at the level of generative coherence. Both are equilibria of a dynamical system in a generalized sense, but the breaking patterns that produce "utility-maximizing agents" versus "minimum-energy configurations" are sufficiently distinct that their conflation typically generates more confusion than insight. The disanalogy is itself evidence: the breaking patterns differ in ways that matter.

The methodological lesson is that a careful epistemology of ontic concept-symmetry requires equal attention to where symmetries hold and where they do not. The cases where they fail to extend reveal the precise grain of the underlying structure.

5 The Operation of Ontic Concept-Symmetry

We now describe operational tools for working with ontic concept-symmetries. These tools are not exhaustive; they are the mathematical languages we judge most fruitful for the present thesis. Other tools—algebraic topology, category theory, stochastic process theory—are sketched briefly at the end of this section.

5.1 Group theory

Group theory is the canonical language of symmetry. A symmetry of a structure X is, in the technical sense, an automorphism of X—a map $X \to X$ that preserves the relevant structure. The collection of all such automorphisms forms a group, the symmetry group of X. Symmetry-breaking, in this language, is the specification of a subgroup: a system has the symmetries of G before breaking, and the symmetries of $H \subset G$ after.

This formal apparatus is directly useful for ontic concept-symmetry. Given a structure Σ with symmetry group G, the diversity of domain-specific concepts arising as broken realizations of Σ corresponds to the diversity of subgroup chains $G \supset H_1, H_2, \ldots$. The classification of such chains—the subgroup lattice of G—is in principle a classification of the conceptual diversity that Σ can generate.

Representation theory adds further depth. A representation of a group G is a homomorphism $G \to \mathrm{GL}(V)$ for some vector space V; in physical terms, a way of realizing the symmetries of G as linear transformations of a state space. Different representations correspond to different ways the same symmetry can manifest. The thesis of ontic concept-symmetry, in representation-theoretic terms, asserts that domain-specific concepts are different representations of a common underlying group, broken in different ways.

5.2 Field theory

Field theory, particularly gauge field theory and its mechanism of spontaneous symmetry-breaking, is the paradigm case of generative breaking in modern physics. The Higgs mechanism, in which an originally symmetric field configuration spontaneously breaks to a less symmetric one and thereby generates the masses of elementary particles, is the locus classicus.

Two features of field-theoretic symmetry-breaking are of philosophical interest for our thesis. First, the breaking is genuinely *generative*: structures that did not exist before the breaking (e.g., the masses of particles, the distinction between weak and electromagnetic forces) come into being through it. Second, the breaking is intelligible: the pre-breaking symmetry is mathematically characterizable, the breaking pattern is mathematically characterizable, and the post-breaking structure follows by deduction from the two.

These features, we suggest, are not specific to physics. The conceptual generativity of symmetry-breaking is, on our thesis, a general feature of the relation between underlying ontic

structure and domain-specific manifestation.

The contemporary research programme of *Group Field Theory* [Oriti, 2006, Smolin, 2017] extends these ideas to questions of quantum gravity. Although technical and far from settled, GFT articulates an approach in which spacetime itself is generated from a more fundamental symmetric structure through a kind of symmetry-breaking. If correct, GFT would be a striking instance of our thesis at the deepest level of physical inquiry.

5.3 Dynamical systems theory

Dynamical systems theory provides a third operational tool. A dynamical system is, in essentials, a flow on a manifold; the relevant phenomena are equilibria, attractors, periodic orbits, and bifurcations.

Symmetry-breaking in dynamical systems takes the form of *bifurcation*: a smooth change in a control parameter induces a qualitative change in the structure of the system. A pitchfork bifurcation, for example, is a paradigmatic generative event: a single equilibrium splits into multiple equilibria, with the new equilibria related to one another by a residual symmetry that reflects the broken structure.

Bifurcation theory has been applied with success to problems in physics, ecology, economics, and neuroscience. In each case, the pattern is the same: a parameter passes through a critical value, the symmetry of the system breaks, and a new conceptual vocabulary becomes appropriate. We claim, on the basis of this consistency, that bifurcation is not a domain-specific phenomenon but the dynamical-systems-theoretic face of ontic concept-symmetry generation.

5.4 Other tools

We mention three further tools whose deeper integration into the present thesis we leave to future work.

5.4.1 Algebraic topology

Algebraic topology classifies spaces by their invariants under continuous deformation. Of particular relevance is the theory of *topological defects*: when a symmetry breaks, the resulting field configuration may contain stable defects (vortices, monopoles, domain walls) whose existence and types are classified by homotopy groups. The persistence of defects is a topological consequence of the breaking pattern. We expect that ontic concept-symmetries of sufficient depth will admit topological-defect analogues: domain-specific "conceptual defects" that mark the trace of the underlying symmetry.

5.4.2 Category theory

Category theory, particularly in its applied forms [Baez & Stay, 2010, Spivak, 2014], offers a meta-language for cross-domain structural identity. A functor between categories is, formally, a way of translating one domain into another that preserves the relations characteristic of each. A natural transformation is a way of comparing such translations. The thesis of ontic concept-

symmetry can be reformulated in categorical terms as the assertion that domain-specific concepts are objects related by functors that preserve underlying structural features.

5.4.3 Stochastic and information-theoretic tools

The information-theoretic equivalence of entropy across domains, mentioned in Section 3, suggests that information theory is a further tool for identifying ontic concept-symmetries. Stochastic process theory more broadly, and its connections to dynamical systems via the theory of random dynamical systems, provides additional formal apparatus.

6 Case Studies

We now present four case studies. Each is a candidate for an ontic concept-symmetry; each is preliminary in its development; each is intended to illustrate the thesis without exhausting its content.

6.1 Case 1: Pareto optimality and dynamical equilibrium

The two concepts. *Pareto optimality* is a concept from welfare economics: a state of an economy is Pareto-optimal if no agent can be made better off without making another worse off. *Dynamical equilibrium* is a concept from dynamical systems theory: a state x^* of a system $\dot{x} = f(x)$ is an equilibrium if $f(x^*) = 0$.

The structural correspondence. Both concepts are characterizations of *stationarity*. In the welfare-economic case, stationarity is with respect to the gradient operator on a multi-objective utility space: a state is Pareto-optimal if the cone spanned by the gradients of agents' utility functions has empty interior of feasible directions. In the dynamical-systems case, stationarity is with respect to the flow vector field. The two are the same structural fact: a vanishing of a generalized variational operator on a manifold of states.

The underlying Σ. The common ontic structure is, we suggest, that of a stratified manifold of variational equilibria—a structure studied independently in singularity theory [Thom, 1989] and the calculus of variations. The Pareto frontier is, in this language, a manifold of generalized equilibria of an associated dynamical system.

The breaking patterns. In welfare economics, the breaking pattern that produces "Pareto optimality" as a domain-specific concept is the privileging of *individual utility* as the variable of variation, and the imposition of an ordinal rather than cardinal structure on the resulting space. In dynamical systems theory, the breaking pattern privileges *state evolution* as the relevant variation, with no privileged direction. The same underlying Σ generates two distinct concepts under two distinct breaking patterns.

Predictive transfer. Bifurcation theory, developed in the context of dynamical systems, has been profitably applied to the analysis of welfare-economic equilibria [Guesnerie, 1986]. This is the predictive transfer that warrants the claim of ontic concept-symmetry.

6.2 Case 2: Marginal states and fiber bundles

The two concepts. *Marginal analysis* in economics studies the rate of change of one quantity with respect to another at a given state: marginal utility, marginal cost, marginal product. *Fiber bundles* in differential geometry are spaces in which a base manifold is locally a product with a fiber, with the cotangent bundle T^*B being the canonical case of a bundle whose fiber over each base-point b is the cotangent space $T^*_b B$.

The structural correspondence. The marginal of a function $U : B \to \mathbb{R}$ is, formally, its differential $dU \in \Gamma(T^*B)$—a section of the cotangent bundle. The economic concept of "the margin" is therefore, structurally, a section of a cotangent bundle. The set of indifference curves of U is the foliation of B by level sets of $dU = 0$, which is the topological structure of a foliation transverse to the cotangent bundle.

The underlying Σ. The underlying ontic structure is that of a manifold equipped with a differentiable function (a "potential"), together with the cotangent bundle that captures its infinitesimal variation.

The breaking patterns. In economics, the breaking pattern privileges a specific potential (the utility function) and a specific physical interpretation (consumption space). In differential geometry, the structure is studied without commitment to any particular potential or interpretation. The economist sees "marginal utility"; the geometer sees "the differential of a function"; both are realizations of the same underlying structure.

Predictive transfer. Differential-geometric techniques (Lie derivatives, Stokes' theorem, integration on manifolds) are directly applicable to economic problems. The Black–Scholes formula in financial economics, for example, is a direct application of stochastic differential geometry to a problem framed in terms of marginal analysis. Predictive transfer is therefore well-attested.

6.3 Case 3: Entropy across domains

The phenomenon. The same functional form, $H = -\sum p_i \log p_i$, surfaces independently in statistical mechanics (Boltzmann), information theory (Shannon), and statistics (Rényi). The von Neumann entropy of quantum mechanics, $-\mathrm{tr}(\rho \log \rho)$, is the natural quantum generalization. Topological entropy of dynamical systems is yet another instantiation.

The underlying Σ. The common structure is, on a categorical reading, the unique (up to scaling) functor from a category of probability distributions to the real numbers satisfying certain naturality conditions. Baez et al. [2011] have shown that Shannon entropy is characterizable as

the unique such functor, suggesting that the ontic structure underlying the various entropies is a categorical universal property.

The breaking patterns. In statistical mechanics, the breaking pattern privileges energy-conservation as the relevant invariant; in information theory, it privileges encoding-efficiency; in statistics, it privileges parametric estimation. The same underlying Σ surfaces under three distinct privileging-patterns.

Predictive transfer. Maximum-entropy methods, developed first in statistical mechanics, are now standard tools in machine learning, ecology, and statistical inference more broadly. The transfer is one of the best-attested in the sciences.

6.4 Case 4: Critical phenomena and tipping points

The phenomenon. Phase transitions in condensed matter physics, tipping points in ecological systems, regime shifts in economics and climate science, and bifurcations in dynamical systems share the structure of a singular qualitative change in system behavior at a critical value of a control parameter. Universality classes in critical phenomena—the observation that diverse physical systems show the same critical exponents at their transitions—is itself a striking confirmation of underlying structural unity.

The underlying Σ. The common ontic structure is that of a parameterized family of dynamical systems at a critical parameter value at which the qualitative structure of the dynamics changes. The renormalization group, originally developed for critical phenomena in physics, provides a powerful mathematical apparatus for analyzing this structure.

The breaking patterns. In physics, the breaking pattern privileges thermodynamic variables; in ecology, ecological state variables; in economics, macroeconomic indicators. The same underlying critical structure surfaces under different choices of relevant variable.

Predictive transfer. Renormalization-group techniques have been applied with success to ecological and economic systems [Scheffer, 2009], providing predictive insight that would not be available from domain-specific analysis alone.

7 Discussion

7.1 Limitations of the present account

Several limitations of the present account deserve explicit acknowledgment.

First, the working definition of ontic concept-symmetry (Definition 1) leaves the precise sense of "representation in the technical sense" under-specified. We have indicated that the relevant notion is to be cashed out via the representation theory of groups and via category-theoretic functoriality, but a rigorous unification of these two senses remains outstanding work.

Second, the argument for the existence of ontic concept-symmetry is an inference to the best explanation. We have argued that the alternative explanations are inadequate, but inferences of this form are defeasible. A more direct argument—perhaps from features of mathematical structure itself, or from the success of cross-domain prediction—would strengthen the position considerably.

Third, the case studies in Section 6 are illustrative, not demonstrative. Each would benefit from detailed development to the level of mathematical rigor that the thesis ultimately requires.

Fourth, the relation of our thesis to current work in the philosophy of physics, particularly to ontic structural realism and to debates over the status of mathematical structures, deserves more sustained attention than we have given it here.

7.2 Alternative explanations and their inadequacies

We here address briefly three alternative accounts of the phenomena that motivate our thesis, and indicate where we judge each inadequate.

The Wignerian view. Wigner's celebrated essay [Wigner, 1960] treats the "unreasonable effectiveness" of mathematics as a fact to be marveled at but not explained. Our thesis offers an explanation: the effectiveness of mathematics is not unreasonable but reflects a structural feature of being. Wigner's silence on the question is not a refutation but an indication of the explanatory work our thesis is positioned to do.

The Kantian view. A neo-Kantian account would treat cross-domain structural recurrences as features of the conceptual schemes through which we organize experience. We have argued (Section 3) that this view fails to account for predictive transfer: predictive success across domains is a mark of mind-independent structure, not of a feature of cognition.

The pragmatic view. A pragmatist account would explain cross-domain recurrence as the result of evolutionary or social convergence on tools that work. This account has merit but is incomplete: it explains why we use similar tools without explaining why the structures these tools track are themselves similar. The pragmatic view, on our reading, presupposes the very phenomenon it is meant to explain.

7.3 Related work

The present thesis stands in a complex relation to several existing research programmes.

Ontic Structural Realism. Ladyman & Ross [2007] have advanced a metaphysical position—ontic structural realism—according to which the fundamental level of reality is structural rather than substantival. Our thesis is closely related to OSR but extends it in two directions: from physics to the cross-disciplinary domain, and from a static structural account to an account that foregrounds generativity through symmetry-breaking.

Group Field Theory and quantum gravity. The research programme of Group Field Theory [Oriti, 2006, Smolin, 2017] aims to derive spacetime itself from a more fundamental symmetric structure through a process of effective symmetry-breaking. While the technical details of GFT are far from settled, the philosophical commitments of the programme align closely with our thesis.

Applied category theory. The recent flourishing of applied category theory [Baez & Stay, 2010, Spivak, 2014, Fong & Spivak, 2019] has provided a powerful mathematical language in which cross-disciplinary structural identity can be made precise. We see our thesis as a philosophical companion to this technical project.

Process philosophy. Whitehead [1929] articulated a metaphysics of process in which becoming is more fundamental than being. Our emphasis on generativity through symmetry-breaking is consonant with this Whiteheadian commitment, though we situate it within a more mathematically articulated framework.

Difference and the virtual. Deleuze [1968] developed a metaphysics in which difference is a generative principle and in which the actual is conceived as the broken realization of a virtual structure. Our thesis can be read as a mathematical articulation of a Deleuzean position: the virtual is Σ, the actual is its broken realization, and difference is the breaking pattern.

Relational and Eastern ontologies. The view that beings are constituted by their relations rather than by intrinsic properties is associated in Western philosophy with Spinoza and (in a different form) with the relational interpretation of quantum mechanics [Rovelli, 1996]. Closely related views are found in the Buddhist doctrine of dependent origination (*pratītyasamutpāda*) and in Daoist relational thought. The present thesis is hospitable to these traditions: the structure Σ is itself relational, and the concepts that arise from its breaking are realizations of relational rather than substantive identity.

7.4 Open questions

Several questions remain open, and we conclude this discussion by listing them.

1. How is the underlying structure Σ to be identified in any given case? Is there a general method, or must each case be analyzed on its own terms?

2. What is the ontological status of Σ itself? Is it a Platonic object, a feature of physical reality, a relational structure, or something else?

3. When is symmetry-breaking constitutive of a concept (i.e., the concept could not be otherwise), and when is it merely descriptive (i.e., a contingent specialization)? This distinction matters for assessing the modal force of the thesis.

4. How does the thesis interact with the failure cases discussed in Section 4? A complete account of ontic concept-symmetry must explain not only its successes but also its limits.

5. What are the methodological implications for the practice of cross-disciplinary research? If the thesis is correct, then certain research strategies (e.g., systematic search for symmetry-counterparts of recalcitrant concepts) are recommended; the empirical productivity of such strategies is itself a test of the thesis.

8 Conclusion

We have proposed a thesis—the *Ontic Symmetry of Concepts*—and argued, preliminarily, for its plausibility, its epistemic accessibility, and its operational fruitfulness. The thesis comprises two coupled claims: that core concepts across distinct domains share a real structural symmetry at the ontic level, and that the diversity of domain-specific concepts arises through symmetry-breaking of this underlying structure. The view explains why mathematical structures recur across the sciences without resorting either to mystery (Wigner) or to relativism (Kant): the recurrence is a trace of being, not an artifact of representation.

We have indicated three operational tools—group theory, field theory, and dynamical systems theory—through which the thesis can be developed. We have illustrated it with four case studies drawn from welfare economics, differential geometry, statistical mechanics, and the theory of phase transitions. We have distinguished it from neighboring positions and indicated its relation to several existing research programmes.

The thesis is preliminary. What we have offered is not a finished theory but a research programme: an articulation of a position, a sketch of its operational tools, and a list of open questions. The work of bringing the thesis to maturity will require sustained engagement with each of the technical apparatuses we have indicated, with the philosophical traditions to which the thesis is heir, and with the empirical sciences whose recurrences first motivated it.

If the thesis is correct, then the apparent fragmentation of the sciences into mutually opaque disciplinary languages is itself the broken image of an underlying unity. The conceptual diversity that confronts the cross-disciplinary researcher is not a primitive obstacle but a generated feature, and its underlying structure is in principle accessible to mathematical articulation. The unity of the sciences, on this view, is not a programmatic hope but an ontic fact that awaits patient and rigorous recovery.

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