On Laws between Contexts

Social-Scientific Laws as Functorial Invariants

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Abstract. Cross-context regularities such as Okun's Law hold across systems that generate them through demonstrably different mechanisms. Universalist accounts of social-scientific laws founder on their locality; invariance accounts operate within single systems; mechanism-based accounts of extrapolation predict failures that practice does not deliver. I argue that social-scientific laws are functorial invariants: each rule-constituted context is a small category whose objects are variables and whose morphisms are causal dependencies, and a law is the structure that functors between such categories preserve. Universal constructions reconstruct pattern-talk without reification; the faithful–full–equivalence hierarchy grades preservation. Okun's Law and Duverger's law illustrate the framework.

Keywords: laws; social science; category theory; extrapolation; structural realism; Okun's Law; Duverger's law

1 Introduction

What kind of thing is a law that survives the replacement of every mechanism that produces it? Across seventy-one economies, advanced and developing alike, changes in aggregate unemployment track changes in aggregate output with striking consistency (Ball et al. 2019). Economists call the regularity Okun's Law and invoke it as a textbook case of a stable empirical law in macroeconomics. Yet the economies it covers produce it through demonstrably different mechanisms: layoffs and rehires in the United States, hour reductions and labor hoarding in Germany, productivity and bonus adjustment in postwar Japan, informal-sector absorption in many developing economies. These are not parameter variations of a single mechanism but different causal pathways with different actors and different institutional preconditions. The puzzle is that applied economists extrapolate the regularity across these contexts and are not wrong to do so; the regularity holds, and a recent cross-country study finds that the mechanism-level features one would most expect to predict cross-context stability fail to do so consistently (Ball et al. 2019).

I argue that social-scientific laws are functorial invariants: structural correspondences preserved by structure-preserving mappings between rule-constituted contexts, rather than universal generalizations, mechanism-tied regularities, or stability profiles internal to single systems. The claim draws on category theory in its proper technical sense. Each rule-constituted context is represented as a small category whose objects are causally relevant variables and whose morphisms are causal dependencies among them; functors between context-categories encode systematic correspondences of causal structure; a law is what such functors preserve. Section 2 situates the view against the current debate. Section 3 develops the framework. Section 4 applies it to Okun's Law. Section 5 extends the reading to Duverger's law, the canonical lawlike regularity of political science.

2 The Debate over Laws in the Social Sciences

Cross-context regularities like Okun's Law sit awkwardly with each of the major philosophical accounts of lawlikeness in the social sciences, though each account locates the difficulty differently. Four families of answers in the current literature frame the debate: (i) the diagnostic tradition of Cartwright and Mitchell; (ii) the invariance and stability accounts of Woodward and Lange; (iii) Steel's mechanism-based account of extrapolation; and (iv) the structural-realist program of Kincaid, Ladyman, and Ross. A fifth body of work, category-theoretic philosophy of science, has developed largely in connection with physics and supplies formal resources that have not yet been brought to bear on the debate. Each of the first four families addresses something its predecessors did not, leaving a specific question open. All four also take a stand, explicitly or not, on the prior question of whether the social sciences have laws at all, pressed head-on by Roberts (2004) against Kincaid (1996); the present paper sides with the defenders while relocating what lawhood consists in.

2.1 Local lawfulness and single-system criteria

Cartwright has argued, across three decades, that scientific laws do not function as universal generalizations (Cartwright 1983, 1989, 1999). Regularities are produced, in her view, by nomological machines: stable arrangements of capacities operating in stable environments (Cartwright 1999, p. 50). Mitchell (2009) complements this diagnosis by tracing the law/non-law binary to its representational source. Representing laws as universally quantified conditionals imposes a dichotomous structure on what is in fact a continuum of degrees of contingency and stability. Together, these positions establish that universalism is untenable and that lawfulness in the social sciences is local and graded. The diagnostic

insight is correct and load-bearing for what follows. What the tradition does not provide, however, is a positive account of cross-context comparison. Cartwright's machines identify pockets of lawfulness without an account of multiple realizability, or of what, if anything, relates machines that generate convergent regularities through different internal arrangements. Mitchell's continuum identifies degrees of stability without an account of what stability consists in: the continuum is posited rather than analyzed, leaving open what grounds the differences in degree.

The project of specifying positive, non-universalist criteria has been pursued most systematically by Woodward and Lange. On the interventionist account (Hitchcock and Woodward 2003; Woodward 2003), a generalization is law-like to the degree that it is invariant under a range of interventions. Lange (2000) offers a parallel account on which laws are propositions stable under nested sets of counterfactual suppositions. Both views share the structure the present account requires, being graded, non-universalist, and applicable in principle to the social sciences; but both operate internal to a single system. Lange's counterfactual suppositions are counterfactuals about the target system; Woodward's interventions are interventions within a specified causal structure. The interventionist framework does not supply criteria for when two distinct systems count as instances of "the same" invariance-structure, and it is this cross-context question that Steel, the structural realists, and the account developed below address.[1]

2.2 Steel and mechanism-based extrapolation

Steel (2008) begins from what he calls the extrapolator's circle: warranting the inference from a causal relationship in a model system to a target requires knowing enough about the target to license the inference, yet if one knew that much, one would not need to extrapolate. His solution is comparative process tracing. If a mechanism M produces an effect E in the model system, and there is independent evidence that M, or a relevantly similar mechanism, operates in the target, the extrapolation is warranted. The unit of cross-context preservation, on this account, is the mechanism.

Steel's account is the most systematic philosophical treatment of extrapolation in biology and the social sciences, and it engages the Cartwrightian tradition directly on capacities and *ceteris paribus* laws. Its central commitment carries a substantive restriction: where mechanisms differ substantially, extrapolation is not warranted. Section 4 will argue that Okun's Law is a counterexample to this restriction. The regularity holds across economies generating it through demonstrably non-homologous mechanisms, and applied economists extrapolate it successfully.

An immediate reply is available to Steel's defender. The "relevantly similar mechanism" clause is elastic: layoffs, hour reductions, productivity adjustment, and informal-sector absorption can all be redescribed as instances of a single abstract mechanism, slack-absorbing adjustment to aggregate demand shocks. So described, the four cases share a mechanism after all, and Steel's framework warrants extrapolation among them. The reply has force, and it is addressed in detail in §4.3. The short version: the reply succeeds in identifying an abstract mechanism shared across the cases, but does so at a level of abstraction Steel's framework does not fix. Slack-absorbing adjustment is one candidate; employment-adjustment-to-demand is another, broader candidate covering the same cases; any adjustment whatsoever is a third; ad hoc disjunctions of the original mechanisms are a fourth. Steel's framework supplies no principled way to rule in one and rule out the others. The account developed in §3 does. The problem and its resolution have a physics analogue worth naming. Renormalization-group explanations of universality show why systems with heterogeneous microdynamics share macrobehavior, and Batterman (2000) argues that multiply realized special-science regularities are best understood on that model. The functorial account can be read as the social-scientific counterpart: functors between rule-constituted contexts, rather than coarse-graining flows, certify which abstractions are principled.

2.3 Structural realism

One program is close enough to the view defended here to require explicit distinction. Kincaid (2008) argues that structural realism, the thesis that what our best theories get right are relational-structural rather than intrinsic properties, is instantiated in social science. He shares the core commitment developed in §3: relational structure, not intrinsic features or mechanism identity, is what travels across contexts and grounds explanation in the social sciences. Kincaid's position connects to the broader structural-realist program of Ladyman (1998) and Ladyman and Ross (2007), on which the commitment to structure is general across the sciences.

Structural realism supplies a metaphysical position: social structures, or relational-structural facts generally, are what scientific inquiry discloses, and their invariances ground explanation. What it does not supply is a formal means of identifying which structural correspondences obtain between which contexts, of distinguishing grades of correspondence, or of determining when a cross-context regularity reflects genuine structural preservation rather than reduced-form artifact. Structural realism tells us what kind of thing to look for; it does not tell us how to find it, compare it across cases, or grade its strength.

Structural realism and the functorial framework are therefore complementary rather than competing. Structural realism supplies the metaphysical orientation; the functorial framework supplies the formal resources that orientation requires.

[1] A determined Woodwardian may object that invariance-under-a-range-of-interventions already crosses contexts, since the "range" may include varying background conditions. The reply has force but does not close the gap. Variation within a single causal structure is a different matter from the existence of two causal structures sufficiently related to support inference from one to the other. What the interventionist account lacks, and what the functorial framework supplies, is a formal means of grading cross-context preservation and of representing the mapping between systems rather than only the invariances within one.

2.4 Category theory in philosophy of science

A distinct body of work develops category-theoretic resources for philosophy of science, concentrated in philosophy of physics. Halvorson (2012, 2019) argues that category theory supplies the right formal setting for the semantic view of theories; Weatherall (2016) uses categorial equivalence to adjudicate questions of theoretical equivalence between physical theories; Landry's (2017) edited volume collects related work, and Bain (2013) develops category-theoretic resources for ontic structural realism.[2] The commitment these authors share, that category-theoretic structure is the right target for philosophical analysis of scientific theorizing, is extended here to the social sciences, with a modification. Where the physics-oriented literature typically takes theories or their models as the objects of the relevant categories, the account developed below takes rule-constituted contexts as objects, represented as categories whose internal structure encodes causal dependencies, and takes functors between context-categories as the bearers of cross-context structural preservation. The modification is motivated by the subject matter: social science is concerned less with axiomatized theories than with structured contexts whose regularities may or may not be preserved across cases.

2.5 The gap: cross-context comparison without mechanism identity

The four families leave a specific question open; the fifth supplies resources that have not yet been applied to it. Cartwright and Mitchell diagnose the failure of universalism without a positive cross-context account. Woodward and Lange give positive accounts restricted to single systems. Steel supplies a cross-context account tied to mechanism identity, or, on the reply in §2.2, to an unspecified level of mechanism abstraction. Structural realism defends the correct metaphysical position without supplying the formal resources that position requires. What is needed is an account that is (i) cross-context, not restricted to single systems; (ii) independent of mechanism identity; (iii) able to grade structural preservation systematically; (iv) ontologically parsimonious, not reifying patterns as second-tier entities; and (v) formally articulated.

3 The Functorial Framework

This section builds the account. The vocabulary is category-theoretic and is used in its proper technical sense, not as a heuristic analogy but as the formal object to which the philosophical thesis refers. The thesis, once the framework is in place, is that social-scientific laws are functorial invariants: structural correspondences preserved by structure-preserving mappings between rule-constituted contexts.

[2] See also the broader applied-category-theory program represented by Baez and Stay (2011) and Fong and Spivak (2019).

3.1 Rule-constituted contexts as categories

Each rule-constituted context, whether a specific legal regime, an economic system, or an institutional configuration, may be treated for analytical purposes as a small category.[3] A context is individuated by the variables defined within it and the causal dependencies among those variables. Both are partly constituted by the context's rules, roles, and conventions: which variables are defined (what counts as unemployment, what counts as a transaction, what counts as a vote) and how they depend on one another (what causal pathways are available, which are foreclosed) depend on the rule-structure of the context. A rule-constituted context, on this treatment, is a causally structured system whose causal structure is in part rule-determined.

For each rule-constituted context C, let $\mathrm{Ob}(C)$ be the collection of variables defined within C, and $\mathrm{Mor}(C)$ the collection of causal dependencies among those variables. A morphism $f\colon X \to Y$ is thus a type-level causal dependence of Y on X, the kind of structural dependence posited by a structural-equation model, not a token causal pathway.[4] Where C contains multiple distinct dependencies from X to Y, two different channels by which Y depends on X, these are represented as distinct parallel morphisms. Composition is causal chaining: if $f\colon X \to Y$ represents Y's dependence on X and $g\colon Y \to Z$ represents Z's dependence on Y, then $g \circ f\colon X \to Z$ represents the composite dependence of Z on X running through Y.[5] The identity morphism $\mathrm{id}_X\colon X \to X$, required by the definition of a category, marks X's trivial structural relation to itself; it is a formal feature of the representation rather than a substantive claim about self-causation (Mac Lane 1998, pp. 7–9).

The choice of causal dependencies as morphisms is not the only possible choice. Morphisms could instead encode insti-

[3] The claim is not that rule-constituted contexts are categories in any metaphysically loaded sense; it is that representing them as categories is analytically fruitful, parallel to Cartwright's representation of experimental arrangements as nomological machines (Cartwright 1999, pp. 49–52). The representation idealizes, as all scientific representation does, and it earns its keep by what it enables the philosophical analysis to do. I use "rule-constituted" rather than "normative" to avoid the misreading on which "normative" carries moral or evaluative weight; the sense at issue is the sense in which institutions are individuated by the rules, roles, and conventions that structure them. The notion descends from Wittgenstein's (1953) treatment of rule-governed practices through the constitutive-rule tradition of Searle (1995); Guala (2016) develops it for contemporary social ontology.

[4] The type/token distinction matters for §4: layoffs and hour-reductions in §4.2 are distinct type-level causal pathways, represented as distinct parallel morphisms within their respective context-categories, not as multiple tokens of a single type-level morphism.

[5] Associativity of composition is secured by the same considerations that underwrite it in Markov categories (Fritz 2020; Cho and Jacobs 2019), where morphisms are (conditional) stochastic maps and composition is Kleisli composition of Markov kernels; associativity there is a theorem about iterated integration rather than an independent postulate about causal chaining. The present construction can be read as the deterministic fragment of such a category, in the following sense: in a Markov category, a morphism is deterministic when it commutes with the copying operation, and in the concrete category of Markov kernels this singles out exactly the kernels concentrated on a single point, that is, ordinary functions (Fritz 2020). The deterministic morphisms form a subcategory, and it is in a subcategory of this kind that the type-level dependencies of the body text live: associativity is inherited from Kleisli composition, and the probabilistic content is bracketed rather than denied.

tutional relations, jural relations, or role-occupancy relations, and for some purposes they should. The present choice is motivated by the case study in §4 and by the direct connection it affords to the interventionist tradition of Woodward (2003); the framework developed here extends to richer choices of internal structure without substantive modification.

3.2 Functors between contexts

A mapping between two rule-constituted contexts, represented as categories, is a functor when it preserves the category structure. Let C and D be rule-constituted contexts. A functor $F\colon C \to D$ consists of two assignments: of each variable $X \in \mathrm{Ob}(C)$ to a variable $F(X) \in \mathrm{Ob}(D)$, and of each causal dependency $f\colon X \to Y$ in C to a causal dependency $F(f)\colon F(X) \to F(Y)$ in D. These assignments must satisfy two conditions: preservation of composition, $F(g \circ f) = F(g) \circ F(f)$, and preservation of identities, $F(\mathrm{id}_X) = \mathrm{id}_{F(X)}$ (Mac Lane 1998, pp. 13–14). A functor, so defined, is a systematic correspondence between the causal structure of C and the causal structure of D that respects how causal dependencies chain.

Functoriality is a substantive constraint. Most set-theoretic assignments from $\mathrm{Ob}(C)$ to $\mathrm{Ob}(D)$, extended arbitrarily to morphisms, will fail either composition-preservation or identity-preservation. A functor is a genuine structural correspondence, not an arbitrary pairing of variables. When a functor exists between two rule-constituted contexts, the two are structurally related in the sense relevant to social-scientific law: the causal structure of one is systematically reproduced in the causal structure of the other, up to the correspondence the functor specifies.

Three features of this setup are worth emphasizing against the alternatives canvassed in §2. First, the existence of a functor between two contexts is a question distinct from whether they share mechanisms (Steel), whether a given generalization is invariant under interventions within each (Woodward), or whether they share metaphysical structure in Kincaid's sense. Functoriality is a formal criterion with determinate satisfaction conditions; the other criteria are either informal or internal to single systems. Second, a functor is a directed mapping, not a symmetric relation of similarity. Talk of "structural similarity" in the informal literature frequently conflates the direction of the mapping with its content; the vocabulary adopted here keeps them distinct. Third, two contexts may admit multiple functors between them, encoding distinct ways of understanding how one maps into the other. Section 3.6 makes use of this fact.

3.3 Laws as functorial invariants

The central thesis can now be stated formally. Let Δ be a diagram consisting of context-categories $C_1, \ldots, C_n$ (with $n \geq 2$) and functors $F_{ij}\colon C_i \to C_j$ for some pairs i, j, with the functors not all identities. A pattern across Δ is a configuration of variables and causal dependencies that each functor in Δ carries from its source to its target. More precisely: a pattern assigns to each context-category C_i in Δ a subdiagram P_i of C_i, and every functor F_{ij} of Δ restricts to a map of P_i onto P_j; the pattern is the family of subdiagrams so matched, not a further entity standing over them. A social-scientific law is such a pattern.

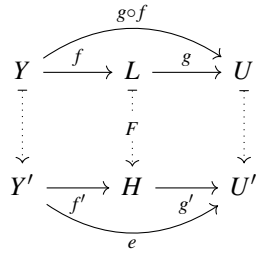

Figure 1: The two toy context-categories of the worked miniature and the action of the functor F (dotted). F sends the American adjustment channel to the German one; the direct dependence e has no preimage under F, so F is faithful but not full. Identities and the composite $g' \circ f'$ are omitted.

On this account, Okun's Law is not an entity; it is the fact that a certain morphism-structure, the causal dependency of aggregate output on aggregate labor-market slack, is preserved by the functors of a diagram of labor-market contexts. There is no additional entity, "Okun's Law," over and above the preserved structure. The law is the preservation, not something independent that the preservation reveals.

This is ontologically parsimonious in a way the alternatives are not. Accounts that posit patterns as a distinct category of entities, abstract particulars that concrete contexts instantiate, owe an account of what such entities are, how they relate to their instances, and how scientific inquiry has epistemic access to them. The present account incurs no such obligations. Patterns are what functors preserve; preservation is a determinate relation between context-categories; no further entities are posited. This aligns the framework directly with the structural-realist commitment, articulated by Ladyman (1998), Ladyman and Ross (2007), and Kincaid (2008), that structure is what there is.

The apparent cost of this parsimony is that pattern-talk, scientists' talk of "Okun's Law" as though it were a single object one can refer to, quantify over, and compare, seems to require patterns as individuals. The cost is only apparent. The universal constructions developed in §3.5 show that patterns-as-such emerge from the functorial framework without additional ontological commitment.

3.4 A worked miniature: two labor markets

The machinery so far is austere; a deliberately small example will fix intuitions before the constructions of §3.5 and §3.6 are introduced. Take two stylized labor markets, impoverished three-variable caricatures of the economies §4 treats seriously. Let C_{US} be a category with three objects, the variables Y (output growth), L (the layoff rate), and U (the unemployment rate), and two generating morphisms

$$f\colon Y \to L \qquad \text{and} \qquad g\colon L \to U,$$

together with the composite $g \circ f\colon Y \to U$ and the three identities. The category says: output shocks change layoffs, layoffs change unemployment, and, by composition, output shocks change unemployment through layoffs. Nothing else is going on.

Let C_{DE} have objects Y' (output growth), H (average hours per worker), and U' (unemployment), generating morphisms $f'\colon Y' \to H$ and $g'\colon H \to U'$, their composite, the identities, and one further generator: a direct dependence $e\colon Y' \to U'$, parallel to $g' \circ f'$ but distinct from it (insolvency-driven separations, say, that bypass hours adjustment). Note that H is a variable here at all only because German labor law constitutes it as one: short-time work (*Kurzarbeit*) is a legally defined status with specified eligibility and compensation, an instance of the rule-constitution of §3.1. The two categories are not isomorphic: C_{DE} contains a parallel pair of channels from output to unemployment where C_{US} contains a single channel.

Now define $F\colon C_{\mathrm{US}} \to C_{\mathrm{DE}}$ on objects by $F(Y) = Y', F(L) = H$, and $F(U) = U'$, and on morphisms by $F(f) = f'$ and $F(g) = g'$. Is this a functor? Identities are preserved by stipulation. For composition there is exactly one thing to check: $F(g \circ f)$ must equal $F(g) \circ F(f) = g' \circ f'$, and it does, since the lone composite of C_{US} is sent to the German composite. So F is a functor, and it is worth pausing over what that did and did not require. It did not require that layoffs and hours reductions be the same mechanism, or homologous mechanisms, or mechanisms sharing a parts-and-operations description; firing workers and shortening their weeks are different things done by different actors under different rules. It required only that the shape of causal mediation correspond: one intervening adjustment variable between output and unemployment, with dependencies that chain. What F preserves, the two-step channel from output to unemployment, is this miniature's Okun's Law. The regularity is not a shared mechanism (there is none) and not a universal generalization (there are only two contexts); it is structure held in common under a structure-preserving map.

The example also shows why preservation must be graded, anticipating §3.6. F is faithful: distinct dependencies in C_{US} have distinct images, so no American causal distinctions are collapsed. But F is not full: the direct channel e lies outside its image, a piece of German causal structure with no American counterpart. The two contexts agree about the Okun channel while disagreeing elsewhere, and the faithful-but-not-full functor records exactly that: agreement on the substructure that matters, without any pretense of overall structural identity.

Finally, form the diagram Δ consisting of $C_{\mathrm{US}}, C_{\mathrm{DE}}$, and F, and consider its colimit, anticipating §3.5. The colimit glues each variable to its image, Y to Y', L to H, and U to U', and glues the American channel to the German one. In the glued category the two channels have become a single composite, and it is that identified channel, not some third Platonic entity hovering above the contexts, that talk of "the pattern" picks out. With one functor and two toy contexts the gluing is admittedly modest; the construction earns its keep when many contexts are glued at once, as in the diagram of economies in §4.5.

3.5 Universal constructions and patterns-as-such

A family of rule-constituted contexts $C_1, \ldots, C_n$ together with functors among them forms a diagram Δ in the category **Cat** of small categories. When such a diagram admits a universal construction, a category built canonically from Δ, that construction gives us a single object to refer to when we speak of the pattern the diagram exhibits.[6] Scientists' reference to "Okun's Law" as a single object is reconstructed, on the present account, as reference to such a universal construction over the diagram of labor-market contexts and their Okun-preserving functors. In the miniature of §3.4, that object is the glued channel itself: the colimit identifies Y with Y', L with H, and U with U', and the two contexts' channels survive as a single composite in the colimit category. A caution attends the gluing image: colimits in **Cat** are computed by generators and relations, so the colimit category can contain composites of the identified morphisms beyond the images of the originals; for the diagrams employed in this paper the freely generated composites are exactly the expected causal chains, but in general the construction is more than pasting.

Two clarifications. First, the formal criterion of lawhood is not the bare existence of a universal construction. **Cat** is complete and cocomplete, so every small diagram admits both a limit and a colimit; existence alone is therefore cheap. What is not cheap is the diagram itself: whether there exist non-identity functors between the contexts that each preserve the candidate structure, and whether the resulting construction is informative, in the sense that the canonical functors into it remain faithful on the structure at issue rather than collapsing it. Where no such functors exist, or where the construction degenerates, the candidate regularity fails the test. The framework thereby leaves open, as a substantive scientific question, whether a given cross-context regularity supports an informative construction. This is as it should be: not every apparent cross-context regularity is a genuine law, and the availability of an informative universal construction over a diagram of structure-preserving functors provides a formal criterion for when it is. Second, which universal construction is appropriate varies with the case. Category theory supplies two main candidates, limits and colimits, which capture different philosophical content. Different cases call for different choices; §4.5 makes the relevant choice for Okun's Law.

[6] The universal constructions at issue are limits and colimits in the sense of Mac Lane (1998, chap. III). A colimit of Δ consists of a category L together with a functor $\iota_i\colon C_i \to L$ for each i, compatible with the functors of Δ (if Δ contains $F\colon C_i \to C_j$, then $\iota_j \circ F = \iota_i$), and universal among such compatible systems: for any other category L' with a compatible system of functors, there is a unique functor $L \to L'$ through which the system factors. Limits are defined dually.

3.6 Grades of structural preservation

Functors differ in what they preserve. A functor $F: C \to D$ is faithful when it preserves distinctness of morphisms: if $f \neq g$ in C, then $F(f) \neq F(g)$ in D. It is full when it preserves the complete morphism structure between any two objects: for every pair $X, Y \in \mathrm{Ob}(C)$ and every morphism $h: F(X) \to F(Y)$ in D, there exists a morphism $f: X \to Y$ in C with $F(f) = h$. It is an equivalence when it preserves and reflects all categorical structure up to isomorphism.[7] These properties form a well-understood hierarchy (Mac Lane 1998, pp. 15, 93).

Grades of preservation correspond to these properties. A faithful functor between two rule-constituted contexts encodes a stronger structural correspondence than a non-faithful one: every causal dependency in the source is distinctly represented in the target. An equivalence encodes a still stronger correspondence: the two contexts are, for the purposes of the functor, structurally interchangeable. These distinctions do philosophical work that natural-language talk of "structural similarity" does not. Claims that two institutional systems, the German social market economy and the Swedish social-democratic model for instance, are "structurally similar" underspecify the preservation relation in ways that matter for which cross-context inferences are warranted. "Structurally similar" behaves, in the informal literature, as Wittgenstein (1953, §§66–67) observed "game" behaves: a family-resemblance term, serviceable in use, that supplies no criterion when a criterion is what the inference requires. The framework names the distinctions and makes them arguable. The functor of the miniature in §3.4 is a case in point: faithful, because it collapses no distinctions among the dependencies of C_{US}, but not full, because the direct channel $e: Y' \to U'$ lies outside its image.

A further application concerns cases in which two investigators propose rival functorial readings of the same pair of contexts. Let $F, G: C \to D$ be two functors between the same rule-constituted contexts, representing two accounts of how C's causal structure maps into D's. A natural transformation $\eta: F \Rightarrow G$ consists of, for each $X \in \mathrm{Ob}(C)$, a morphism $\eta_X: F(X) \to G(X)$ in D, such that for every morphism $f: X \to Y$ in C the equation $\eta_Y \circ F(f) = G(f) \circ \eta_X$ holds (Mac Lane 1998, pp. 16–17). A natural transformation is a systematic comparison between F and G, specifying how their images correspond in a way that commutes with C's morphisms.

Methodological disputes in comparative social science frequently take this form. Two political economists may agree that the US and Germany are structurally related while disagreeing about which variables correspond to which, or which causal dependencies map to which. Their disagreement is a disagreement about the correct functor, and the natural transformation between their proposed functors articulates precisely what the disagreement consists in. This recovers, in formal vocabulary, the intuition that some methodological disputes are substantive while others are merely notational: substantive disputes correspond to the non-existence of a natural transformation between the rival functors; merely notational disputes correspond to the existence of an isomorphism-valued one. The intermediate case, a natural transformation that exists but is not an isomorphism, is not an embarrassment for the dichotomy but its refinement. A non-isomorphic η orders the two readings: each identification F makes is carried by the components η_X into the corresponding identification of G without being recoverable from it, so G stands to F as a coarsening, the relation in which one reading systematically absorbs distinctions the other draws. Disputes of this shape are neither merely notational nor flatly substantive; they are disputes about grain, and the direction in which a non-isomorphic transformation exists tells the disputants which reading refines which.

[7] More precisely, $F: C \to D$ is an equivalence when there exists a functor $G: D \to C$ and natural isomorphisms $F \circ G \cong \mathrm{id}_D$ and $G \circ F \cong \mathrm{id}_C$.

4 Okun's Law as a Functorial Invariant

Okun's Law has held across seventy-one economies, and in the United States for six decades, while being generated, in different economies, through substantially different mechanisms. On a mechanism-identity account of cross-context preservation, extrapolation across such contexts should not be warranted; in practice, applied economists extrapolate the regularity successfully. The case accordingly exhibits the features §3 predicts a functorial invariant should exhibit: a structural correspondence preserved under mappings between contexts whose internal mechanisms differ. The sections that follow set out the regularity (§4.1), document the mechanism heterogeneity that generates it (§4.2), answer the mechanism-abstraction reply available to Steel's defender (§4.3), bring the Ball et al. (2019) evidence to bear (§4.4), and give the functorial reading together with the grade of preservation it involves (§4.5 and §4.6).

4.1 The regularity

Okun's Law, first formulated by Arthur Okun (1962), states a stable negative relationship between changes in aggregate unemployment and changes in aggregate output. The relationship holds across advanced economies, developing economies, and economies in transition, and it has survived multiple structural transformations over six decades: oil shocks, financial deregulation, the Great Moderation, the Great Recession, and the pandemic. The Okun coefficient, which measures the short-run responsiveness of unemployment to output, varies across contexts. Among advanced economies it is roughly 0.45 in the United States, 0.15 in Japan, and 0.85 in Spain (Ball, Leigh, and Loungani 2017); on average it is about half as large in developing as in advanced economies (Ball et al. 2019); it is widely reported to be stronger during recessions than during expansions; and it varies sub-nationally as well as across countries. The sign and structural character of the relationship, however, are preserved across these contexts.

The phenomenon to be explained is therefore a graded, non-universal, but robustly recurring cross-context regularity, precisely what Mitchell's continuum of stability predicts should exist and what Cartwright's patchwork picture leaves unaccounted for.

4.2 Mechanism heterogeneity

The regularity is generated through non-homologous mechanisms in different economies, as a matter of empirical fact documented in comparative labor economics and comparative political economy (Hall and Soskice 2001; Eichhorst and Marx 2011).

In the United States, labor markets are relatively flexible; adjustment to demand shocks proceeds primarily through layoffs, rehires, and movements in labor-force participation. In Germany, strong employment-protection legislation and institutionalized short-time work arrangements (*Kurzarbeit*) route adjustment through hour reductions within firms, labor hoarding, and corresponding productivity swings. In postwar Japan, lifetime-employment norms and bonus-based pay structures produced adjustment through productivity and bonus reductions rather than layoffs. In many developing economies, formal-sector employment is thin; adjustment runs through informal-sector absorption, agricultural buffering, and flows into and out of self-employment.

These are not parameter variations of a single mechanism. They involve different actors, different institutional preconditions, different adjustment speeds, and different welfare consequences for workers. Layoffs-and-rehires is a genuinely different causal pathway from hour-reductions-within-firms, which is a genuinely different pathway from informal-sector absorption. Yet the same structural relationship, aggregate labor-market slack mapping systematically to aggregate output movement, holds across contexts generating it through these different mechanisms. This is the puzzle.

4.3 The mechanism-abstraction reply

A defender of Steel has the reply already sketched in §2.2. Steel's "relevantly similar mechanism" clause is elastic; all four cases in §4.2 can be described as instances of a single abstract mechanism, slack-absorbing adjustment to aggregate demand shocks. Concrete realizations vary, layoffs in one context, hour reductions in another, but the abstract mechanism is shared, and Steel's account warrants extrapolation on the basis of shared abstract mechanisms.

The reply must be met directly, because it threatens to dissolve the puzzle. It should be granted to a point and then pressed. It is granted that an abstract mechanism-description covers all four cases. What the reply does not supply is a principled answer to the prior question: which abstraction is the right one? Slack-absorbing adjustment is one candidate; employment-adjustment-to-demand is another; any adjustment whatsoever is a third; ad hoc gerrymanders are an indefinite fourth family. Steel's framework does not discriminate among these. Once the mechanism-identity criterion is relaxed to admit abstract mechanisms, the question of which abstractions count is left open, and "relevantly similar mechanism" collapses into the intuitive judgment of the extrapolator. The epistemic situation this creates has a familiar shape. An investigator who extrapolates Okun's Law to Germany on the ground of a shared abstract mechanism holds a belief that is justified by Steel's lights and true by the data; but if what sustains the regularity in Germany is structural correspondence rather than mechanism overlap, the justification does not track what makes the belief true. The extrapolation stands to warranted extrapolation as Gettier's (1963) cases stand to knowledge: justified, true, and connected by luck.

This is where the functorial framework supplies what Steel's account lacks. The right abstraction, on the present account, is the one that arises from a universal construction over the diagram of contexts and their functorial relations (§3.5). An abstraction is principled when it is the category-theoretic colimit of a functorial diagram; it is ad hoc when it is not. Slack-absorbing adjustment is a principled abstraction because it corresponds to the structural correspondence that functors between labor-market contexts preserve; any adjustment whatsoever is not, because no informative functorial diagram among labor-market contexts yields it as a universal construction. The framework does not eliminate the question of which abstractions count; it reformulates it in terms with determinate satisfaction conditions. Steel's framework does not supply such terms.

A parallel worry arises for the functorial framework itself: if Steel's account underdetermines which abstraction counts, the functorial account underdetermines which functors populate the diagram. Different choices of Okun-preserving functors yield different colimits. The worry has force but is less severe than its Steel analogue in one respect. Functoriality is an empirically constrained criterion: whether a given assignment of variables and dependencies preserves composition on the data is a question with a determinate answer once the data are specified. A putative Okun-preserving functor that fails composition-preservation on the observed causal structure is falsified by that failure. Steel's "relevantly similar mechanism" admits no comparably determinate falsification; it collapses, as this section has argued, into intuitive judgment. The functorial framework narrows the underdetermination without eliminating it.

4.4 The cross-country evidence

The argument in §4.3 is logical: Steel's framework underdetermines the relevant level of abstraction. Ball et al. (2019) supply a distinct empirical point that further constrains the mechanism-identity view. In a paper pointedly titled "Does One Law Fit All? Cross-Country Evidence on Okun's Law," Ball, Furceri, Leigh, and Loungani examine Okun coefficients across advanced and developing economies and test directly whether mechanism-level features predict cross-country variation. They regress estimated Okun coefficients on candidate explanatory variables including standard indices of overall labor-market and product-market flexibility.

The result is that mechanism-level features do not consistently explain cross-country heterogeneity in Okun coefficients. Labor-market flexibility, the most obvious mechanism-level predictor and the variable most directly indexing the mechanisms described in §4.2, does not play a consistent role; the variables that do correlate with the coefficient, the mean unemployment rate and the service share of output, are not mechanism descriptions in Steel's sense (Ball et al. 2019, sec. 4). The finding should be stated carefully. It is not proof that no mechanism-level account could ever explain cross-context preservation of Okun's Law. It is evidence that the mechanism-level features one would most expect to matter, given the comparative political economy literature that catalogues the mechanism heterogeneity, do not matter in the way the mechanism-identity view predicts.

The philosophical upshot is modest but substantive. The burden of proof shifts to the mechanism-identity theorist to identify which mechanism-level feature does predict cross-context preservation. Until such a feature is identified, the mechanism-identity view is in the position of asserting that mechanism-level facts explain cross-context preservation while the mechanism-level facts that would most naturally do the explaining empirically fail to do so. The functorial framework, by contrast, predicts the Ball et al. result: cross-context preservation tracks structural correspondence, which the measured mechanism-level features do not directly index.

4.5 The functorial reading

The case can now be redescribed in the vocabulary of §3. Let $C_{\mathrm{US}}, C_{\mathrm{DE}}, C_{\mathrm{JP}}$, and C_{dev} be the context-categories associated with the United States, Germany, postwar Japan, and a representative developing economy. Each is a small category whose objects are the causally relevant macroeconomic variables defined within that context (aggregate unemployment, aggregate output, labor-force participation, among others) and whose morphisms are the type-level causal dependencies among them. The objects and morphisms of each context differ: Germany has morphisms representing the causal dependencies that run through *Kurzarbeit* arrangements, which the United States does not; the United States has morphisms representing the causal dependencies that run through layoff-and-rehire cycles, which postwar Japan does not.

Between these contexts there are functors $F_{ij} \colon C_i \to C_j$ that preserve a specific morphism-structure: the causal dependency of aggregate output on aggregate labor-market slack. The functors do not preserve the concrete adjustment-mechanism structure, because that structure is internal to each context and differs across them. The functors preserve what Okun's Law is: the structural correspondence between slack and output, abstracted from the concrete mechanisms that realize it locally.

The universal construction appropriate to the diagram Δ consisting of these contexts and their Okun-preserving functors is a colimit rather than a limit, and the choice is not notational. A limit would take the universal object to be a category that maps into each C_i, intuitively, the common substructure that every context in the diagram contains as a distinguished part. A colimit takes the universal object to be a category that each C_i maps into, intuitively, the quotient formed by identifying corresponding structure across contexts. For the Okun case the colimit is correct. The slack–output dependency is not present as a distinguished substructure in each national labor market; each national market contains its own concrete mechanisms, not the abstracted slack–output pattern. What the functors among national markets do is identify slack–output dependencies across contexts. The colimit is precisely the category formed by this identification. The abstracted pattern "Okun's Law" is a quotient-like construction, not a shared-core construction; this is what the colimit formalizes.

The colimit is constructed from the diagram; it does not exist independently of the contexts and functors that generate it. Russell's distinction (1914, lecture 3) between logical constructions and inferred entities applies directly: Okun's Law is a logical construction from the diagram of labor-market contexts, not an entity over and above them.

Two features of applied economic practice are explained by this reading. First, the practice of using context-specific Okun coefficients while treating Okun's Law as a single regularity is functorial reasoning in ordinary language. The coefficient varies under the functor, being part of the context-specific content the functor does not preserve, while the preserved morphism (the causal dependency between slack and output) is single and structural. Applied economists are not confused when they use different coefficients for different countries and still speak of "Okun's Law"; they are implicitly tracking the distinction between what the functor preserves and what it does not. Second, the cross-country comparability of Okun analysis, absent shared mechanisms, is licensed by functorial correspondence rather than mechanism identity. The Ball et al. finding is not a puzzle on the present view: mechanism-level features do not predict cross-context preservation because preservation is functorial, and functoriality is a constraint on structural correspondence that mechanism-level indices do not directly measure.

4.6 Grades of preservation in the Okun case

The distinctions of §3.6 apply to this case with philosophical payoff. The functors among $C_{\mathrm{US}}, C_{\mathrm{DE}}, C_{\mathrm{JP}}$, and C_{dev} are not equivalences; the contexts are not structurally interchangeable, and a reviewer who claimed they were would be making a much stronger claim than the case supports. The functors are better described as faithful on the restricted substructure concerning slack–output dependencies: in each context-category, designate the subcategory generated by the slack and output variables and the dependencies among them; a functor is faithful on this substructure when its restriction to that subcategory is faithful, which is to say that the morphism-distinctness among slack–output dependencies in each source is preserved in each target. They are not full: there are morphisms in each target that do not arise as images of morphisms in the source, because each context has institution-specific

causal dependencies that others lack.

This is the right grade of preservation for Okun's Law. Too strong a grade, equivalence, would overreach, asserting structural interchangeability that comparative political economy refutes. Too weak a grade, bare existence of a functor, would underreach, failing to explain why the slack–output correspondence is preserved with the specificity it exhibits. Faithful-on-a-subcategory captures the actual structural situation: these contexts share a specific structural correspondence (slack–output dependency) faithfully while differing elsewhere.

Methodological disputes in comparative macroeconomics can now be reconstructed as disputes about which functor is operative. Whether Okun analysis should pool across OECD countries, whether pre- and post-1990 data should be treated as a single regime, whether sub-national Okun estimates for US states should be aggregated into a national coefficient: each is a dispute about which functorial reading correctly captures the structural correspondence. The framework names the question and makes it arguable. Ordinary-language talk of "structural similarity" collapses these disputes into a single undifferentiated register; the functorial vocabulary distinguishes them.

5 A Second Illustration: Duverger's Law

If the framework is right, nothing in it is proprietary to economics, and the way to show this is to run the analysis, in compressed form, on the social-science regularity most often cited alongside Okun's Law in the lawhood literature. Duverger's law states that plurality rule in single-member districts favors two-party competition (Duverger 1954). Riker (1982) famously presented it as the nearest thing political science has to a genuine law, and it has served ever since as the discipline's standard exhibit in debates about social-scientific lawhood. Its modern form is more precise than its textbook statement: the regularity is district-level bipartism, the tendency of the effective number of competitors within a single-member plurality district toward two (Cox 1997), while national party systems built atop those districts vary with how district-level competition aggregates (Chhibber and Kollman 2004). Stated that way, the law has the same profile as Okun's: local, graded, robust within a delimited family of contexts, and recalcitrant to universalist reconstruction.

Electoral contexts are rule-constituted to a degree that makes labor markets look only half-institutional. What counts as a valid vote, a district, a seat, and a registered party is defined by electoral law; and the dependence of seat allocations on vote distributions is not merely causally shaped by rules but fixed by them, since the electoral formula simply is the function from the one to the other. Each plurality context is therefore a rule-constituted context in the sense of §3.1, and the vote–seat morphism is the limiting case of that section's claim that causal structure is in part rule-determined: here the rule determines the morphism outright. Represent a district-level plurality context as a small category whose objects include P (the mechanical penalty: the vote–seat disproportionality facing trailing competitors), E (viability expectations among voters, donors, and potential candidates), and N (the effective number of district competitors), with generating morphisms $P \to E$ (the penalty shapes expectations about who can win) and $E \to N$ (expectations drive strategic desertion, withheld funding, and deterred entry, contracting the field), and their composite $P \to N$: the Duverger dependence.

The mechanisms realizing this channel differ across contexts as starkly as layoffs differ from short-time work. In Britain, the psychological link runs through informed strategic voters responding to national polling and constituency history. In the United States, much of the work is done upstream of the general election: primaries absorb would-be third parties into the major-party apparatus, and ballot-access law deters entry before voters coordinate on anything. In India, voters often do not desert third parties at all; coordination is achieved by elites through pre-electoral alliance formation, so the expectation-sensitive actors are party leaders brokering seat-sharing agreements rather than individual voters (Chhibber and Kollman 2004). In Canada, regionally concentrated parties partially evade the mechanical penalty wherever their support is spatially clustered. A mechanism-identity account of extrapolation faces here exactly the predicament of §4.3: the parts, actors, and operations differ, comparative similarity of mechanisms is low, and yet district-level bipartism extrapolates well across the plurality family (Cox 1997). Practice treats the regularity as projectible; mechanism-identity says it should not be.

The functorial redescription follows the Okun template. Take the diagram whose nodes are district-level plurality contexts, $C_{\mathrm{UK}}, C_{\mathrm{US}}, C_{\mathrm{IN}}$, and C_{CA}, and whose functors map penalty to penalty, expectations to expectations, and competitor-number to competitor-number, while mapping different coordination variables onto one another: British strategic switching onto Indian alliance brokerage, as the miniature of §3.4 mapped layoffs onto hours. What every functor of the diagram preserves is the two-step channel from mechanical penalty through expectations to contraction of the competitor set. That preserved channel is Duverger's law on the present account; the colimit over the diagram supplies the single object political scientists refer to when they speak of the law, without any Platonic regularity standing over the contexts.

The grading hierarchy then converts the textbook 'exceptions' from embarrassments into structure. Functors among Westminster-style contexts approach fullness on the electoral substructure. The functor into the Canadian context is faithful on the channel but not full: regional concentration constitutes a causal pathway, spatially clustered support blunting the mechanical penalty, that has no preimage, the e-morphism situation of §3.4 writ large. India marks the same grade at a different join: at district level the channel is preserved, while the national aggregation structure (federalism and linguistically organized states multiplying party systems across

districts) is structure that no functor from a unitary context covers. That is Chhibber and Kollman's finding redescribed: extrapolation succeeds at the level where the functors are faithful and fails at the level where there is no functor to carry the structure. And rival explanations of a context's conformity, voter-level strategic desertion against elite-level alliance coordination, are rival functorial readings in the sense of §3.6, comparable by natural transformation and discriminable by which variable assignments track.

The second illustration earns three conclusions. First, generality: the framework runs unchanged on a political-science regularity, with objects, morphisms, functors, and grades doing the same work they did for Okun's Law. Second, the rule-constitution thesis gains its clearest instance, a morphism whose existence and shape are fixed by the constituting rule itself. Third, the contrast with mechanism-identity accounts sharpens: where Steel's strategy would send the investigator hunting for mechanism overlap between British strategic voters and Indian alliance brokers, the functorial account locates the law where the discipline's own refinements located it, in a channel preserved at a specifiable grade across a specifiable family of contexts. Cox's extension of the regularity, the tendency of the number of viable candidates toward district magnitude plus one, reads naturally as an enlargement of the diagram beyond pure plurality contexts, with district magnitude parameterizing the family; the framework predicts, testably, that the enlarged diagram should still admit an informative colimit.

6 Conclusion

This paper began from a diagnosis the literature already supplies: lawfulness in the social sciences is local and graded, and the universalist picture is untenable. What the literature does not supply is an account of cross-context comparison that is independent of mechanism identity, capable of grading structural preservation, and formally articulated. The functorial framework meets that need. Rule-constituted contexts are represented as small categories whose morphisms are causal dependencies; functors between context-categories encode systematic correspondences of causal structure; a social-scientific law is a functorial invariant, structure preserved across a diagram of contexts. Universal constructions reconstruct scientists' reference to patterns without reifying them; the faithful–full–equivalence hierarchy grades preservation; natural transformations articulate what rival functorial readings disagree about. Okun's Law exemplifies the analysis: a regularity preserved across economies whose adjustment mechanisms are demonstrably non-homologous, reconstructed as a colimit over a diagram of labor-market contexts, at a grade of preservation (faithful on the slack–output substructure, not full, not an equivalence) that mechanism-identity accounts of extrapolation cannot deliver. The compressed treatment of Duverger's law in §5 indicates that nothing in the analysis is proprietary to economics: the same apparatus runs wherever rule-constituted contexts generate stable regularities across heterogeneous mechanisms.

Two limitations mark the agenda. First, the morphisms employed here encode causal dependencies only; institutional, jural, and role-occupancy relations await parallel treatment, and the interaction between causal and institutional structure within a single context-category is an open formal question. Second, the framework narrows but does not eliminate the underdetermination of the functorial diagram, and the discipline this imposes is ultimately empirical. The natural further test cases are Engel's law and the gravity equation of trade, each of which holds across contexts with heterogeneous mechanisms and each of which the framework predicts should admit an informative functorial reconstruction. Whether they do is a question the framework makes precise enough to ask.

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