MPRA
Munich Personal RePEc Archive

Reversibility as a Factor of Production: A General Theory of the Economics of Error

YAHYA, Ould Amar

Independent searcher

5 August 2026

Online at https://mpra.ub.uni-muenchen.de/130349/
MPRA Paper No. 130349, posted 24 Aug 2026 14:21 UTC

Reversibility as a Factor of Production: A General Theory of the Economics of Error

Yahya Ould Amar

Economist, banker and financier

Graduate of the École Nationale de la Statistique et de l'Administration Économique (ENSAE) – Institut Polytechnique de Paris;
Master's/PhD in Macroeconomic Analysis, Université Paris I Panthéon-Sorbonne;
Master's/PhD in Applied Mathematics, Université Paris-Dauphine.

This article condenses the theoretical apparatus developed in the author's treatise, "The Right to Be Wrong — Error as a Factor of Production" *(KDP Amazon 2026, 9 parts, 42 chapters). Every result stated here is proved or derived there. The present text selects, condenses and formalizes the contribution for a research readership.*

Abstract

This article introduces *reversibility* as a factor of production in its own right. Reversibility is the efficiency with which an economy converts its failures into reusable knowledge while preserving the capacity of agents to try again.

A coefficient $\rho \in [0,1]$, decomposable into five components mounted in series — financial, legal, social, cognitive and political — governs three channels: the accumulation of an unmeasured stock of *experience capital*; the volume of experimentation, through an entry threshold that rationalizes the observed prudence of poor economies; and the depth of hysteresis after shocks.

The interaction of these three channels generates a *conformity trap*, whose geometry is that of the "cusp catastrophe" and whose early-warning signals are refutable.

It also generates an asymmetric law of belief adjustment, the *law of freeze and thaw*, which we microfound as the exact nonlinear filtering of a hidden institutional regime.

On this basis, the article establishes an aggregation theorem for a Reversibility Index; an all-or-nothing optimal-reform result, the *clean-jump theorem*; and a series of amendments to canonical theories — Ricardian trade, the Phillips curve, Modigliani–Miller, the Keynesian multiplier, loss aversion, Eaton–Gersovitz sovereign debt, Holmström–Milgrom contracts — each of which is recovered exactly in the limit $\rho \to 1$.

The construction closes with a general theory: five axioms; an invariant that is the institutional analogue of the Carnot bound; a McKean–Vlasov field equation for the distribution of beliefs; a notion of economic *proper time* whose dilation defines underdevelopment; and a correspondence principle that makes received economic theory the zeroth-order term of an expansion in $(1 - \rho)$. Ten signed predictions and six prohibitions expose the theory to refutation.

1. Introduction

1.1. The question and the thesis

Why does the same failure remain an incident in some societies and become a sentence in others?

Consider two entrepreneurs undergoing identical bankruptcies: same product, same market downturn, same balance sheet filed.

In the first economy, an orderly procedure settles the debts. A judge grants the discharge. An insurer absorbs part of the shock. Investors reread the episode as a stage of learning within a career. The loss wounds but does not destroy: the system absorbs, corrects, refinances.

In the second economy, the same bankruptcy carries away a lifetime of savings, the family estate, access to credit, reputation, sometimes the honor of a name. The event bears the same statistical label; its economic depth is entirely different.

This article argues that the property separating these two worlds — *reversibility*, denoted ρ — belongs in the production function alongside capital and labor. Its omission from canonical models explains a considerable share of the puzzles of underdevelopment, and several puzzles of the rich economies themselves.

The thesis rests on three propositions.

First, error is a raw material of growth: an unsuccessful attempt consumes resources, but it reveals information about technique, demand, organization, credit and behavior. That information has economic value as soon as it is extracted, transmitted and made available for the next attempt.

Second, this raw material yields its value only if the system knows how to recycle it. A society that ruins those who err burns the archives of its own experiments: it pays the full price of experimentation and discards the product.

Third, the capacity to recycle depends on precise, identifiable and reformable institutions: bankruptcy law, social insurance, the depth of capital markets, information registries, the political conditions governing exit from power. Their joint performance can be measured, modeled and governed.

The reading of underdevelopment that follows inverts the usual diagnosis. Poor nations are ordinarily described in terms of scarcities: capital, skills, infrastructure, institutions.

We argue that they suffer first from an *excess* — the excessive price of error. Where every attempt puts an entire life at stake, the rational agent chooses immobility. That choice is wise for the individual and ruinous for the nation. The farmer who refuses the new seed, the student who chooses the safe track, the civil servant who buries the reform, the entrepreneur who prefers liquid trade to heavy industry: all optimize correctly under a constraint that standard models do not write down — a single wrong turn can close off the entire trajectory. Development policy then changes its object. It stops exhorting agents to be brave; it sets about lowering the price of error.

1.2. Contribution in the light of the literature

The article connects several literatures, each of which had grasped one facet of the phenomenon without naming the common variable.

Growth and the residual. Since Solow (1956, 1957), most of the income gaps between countries lodge in total factor productivity — the "measure of our ignorance," in Abramovitz's phrase. We extract from this residual a hitherto hidden component: capitalized institutional reversibility, embodied in a third stock R of *experience capital*, endowed with its own law of accumulation (Section 2). The Lucas paradox (1990) — capital flows too little toward poor countries, and disappoints when it does flow there — receives its missing link: the marginal product of imported capital depends on a flow of local micro-experimentation that low-ρ environments rationally fail to supply.

Endogenous growth. Arrow (1962), Romer (1986, 1990), Aghion and Howitt (1992) make learning proceed from successful activity: cumulative production, completed research, implemented innovation. We add learning from failure, conditioned by institutions. Technical progress becomes the product of a volume of attempts and a conversion efficiency, and ρ enters the growth rate twice: as an efficiency, and as a determinant of the volume. This double presence generates a convexity that grounds both the possibility of take-offs and the cruelty of traps (Section 2.6).

Poverty traps and hysteresis. The trap literature (Rosenstein-Rodan 1943; Nurkse 1953; Nelson 1956; Azariadis and Drazen 1990; Murphy, Shleifer and Vishny 1989; Dasgupta and Ray 1986) shares a single mathematical skeleton: a non-convex map cutting the diagonal three times. Our *conformity trap* has the same skeleton, but a different trapped variable. It is not an accumulable stock; it is an institutional price, the price of failure, whose feedback loop closes through the fiscal and financial channel (Section 4). The distinction is testable: capital injections move the economy along the state axis without deforming the landscape. This is why aid so often fails where the diagnosis of capital scarcity was nonetheless correct. Blanchard and Summers (1986) introduced hysteresis through the labor market; we generalize it to the parameter ρ itself, with an asymmetric adjustment law that is derived from Bayesian filtering rather than postulated (Section 5).

Real options. Dixit and Pindyck (1994) priced the option to wait, the one destroyed by irreversible commitment. We price the symmetric object: the *put option* that reversibility writes on every project. Its value increases with volatility. It follows that the societies facing the greatest turbulence are precisely those for which the right to be wrong carries the highest social return (Section 3.4).

Institutions. Relative to North (1990) and to Acemoglu, Johnson and Robinson (2001; Acemoglu and Robinson 2012), reversibility is a dimension distinct from inclusiveness. An economy can protect property and open entry while crushing those who fail; enclaves of high ρ can prosper within extractive wholes. The two axes intersect without merging, and the dissonant cells of the matrix are privileged terrain for identification.

The general theory. The article finally assembles these components into a single formal system (Section 9): five axioms; an invariant that bounds the economy-wide conversion efficiency of errors, the institutional analogue of the Carnot bound; an equivalence principle — agents cannot locally distinguish the actual institutional regime from the believed one — which constrains the fundamental variable to be a *field*, the distribution of beliefs, governed by a Fokker–Planck–McKean–Vlasov equation with jumps; a mean-field game that microfounds the trap as a coordination failure; a notion of *proper time* under which the law of knowledge accumulation is universal across nations; a

Riemannian geometry of reform sequencing; a variational principle of least dissipation; and a correspondence theorem: every received theory examined is the zeroth-order term of an expansion in $(1-\rho)$, exact where this parameter is negligible, increasingly false as one descends toward the economies where it is not. The nearest neighbors — Georgescu-Roegen's entropy economics (1971), Prigogine's dissipative structures, Holling's resilience (1973), Schumpeter's creative destruction — each lack one or more elements: a law of accumulation, a price, a market failure of its own, a fiscal instrument, a stochastic dynamic, a clock. The intersection was an empty cell. This theory is built to occupy it, and claims nothing beyond that.

Throughout, every formal structure imported from the physical sciences — the cusp, the Kramers time, the fluctuation relation — is subjected to Popper's criterion: it arrives with observable assumptions and a refutable signature, never as ornament. Section 10 gathers the predictions and the prohibitions.

1.3. Outline

Section 2 installs experience capital and the reversibility coefficient in the production function and derives the consequences for growth. Section 3 provides the microfoundations: entry threshold, wealth effects, experimentation careers, option value, moral hazard, socially optimal ρ. Section 4 develops the aggregate dynamics of the conformity trap, its cusp geometry and its early-warning signals. Section 5 derives the law of freeze and thaw and its filtering microfoundation. Section 6 constructs the Reversibility Index and proves the aggregation and allocation results. Section 7 solves the reformer's problem (clean-jump theorem) and the political-stability problem (Kramers time, conservation of anger). Section 8 amends nine canonical theories and shows that each is the special case $\rho = 1$. Section 9 states the general theory. Section 10 draws up the list of what the theory prohibits. Section 11 concludes.

2. Experience capital and the reversibility coefficient

2.1. Definitions and production function

Let $e(t)$ be the flow of errors committed at date t, measured by the value of the resources exposed in attempts that fail. Let $\rho \in [0,1]$ be the *reversibility coefficient* of the environment: the fraction of the informational and material content of failure that the system recovers — through recoverable losses, permitted rebound and the circulation of the lessons drawn. Define *experience capital* $R(t)$ as the accumulated memory of unsuccessful attempts duly analyzed, appropriable by the agent, the organization or society. The aggregate technology is written

$$Y = A\,K^{\alpha}L^{\beta}R^{\gamma}, \qquad \gamma > 0, \qquad (1)$$

and the stock evolves according to the *conversion law*

$$\frac{dR}{dt} = \rho\, e(t) - \mu R(t), \qquad (2)$$

where μ is the rate of obsolescence of lessons: yesterday's errors inform imperfectly about tomorrow's technologies. At the steady state of a constant error flow e,

$$R^{*} = \frac{\rho\, e}{\mu}. \qquad (3)$$

Long-run experience capital is proportional to reversibility. A society that doubles its ρ doubles its stock of useful experience *without committing a single additional error*: institutional reform raises the yield of errors already paid for. This is the theory's first comparative static, and the most useful one for economic policy.

Experience capital has the classical attributes of capital: it accumulates, depreciates, produces returns, requires maintenance. It has one singular property: its formation requires prior destructions. The national accounts record machines, buildings, hours and patents; they leave this asset entirely off balance sheet. They also ignore its negative twin: the mass of projects smothered before their first move — firms never created, reforms left in the drawer — which no instrument counts and which weighs more heavily than the visible bankruptcies.

2.2. Development accounting with the additional factor

Take logarithms of (1) and difference between two countries A and B:

$$\ln\frac{Y_B}{Y_A} = \ln\frac{A_B}{A_A} + \alpha\ln\frac{K_B}{K_A} + \beta\ln\frac{L_B}{L_A} + \gamma\ln\frac{R_B}{R_A}. \qquad (4)$$

In the Solow decomposition, R does not exist: its contribution is credited by default to the residual. Substituting the steady state (3), under the assumption of comparable error flows ($e_B \approx e_A$) and comparable obsolescence rates ($\mu_B \approx \mu_A$),

$$\gamma\ln\frac{R_B}{R_A} = \gamma\ln\frac{\rho_B}{\rho_A}.$$

A cautious calibration suffices to fix the orders of magnitude. With $\gamma = 0{,}15$ and a reversibility ratio of one to three, $0{,}15 \times \ln 3 \approx 0{,}165$, that is, an income gap of about 18 percent through the experience channel alone — before any threshold effect, before the conformity loop of Section 4. The panel evidence assembled in the treatise (112

countries, 22 years; five harmonized sources instrumenting the components of ρ; country and year fixed effects; controls for property rights, human capital and the terms of trade) attributes between 19 and 26 percent of the variance of the Solow residual to the component associated with ρ. The effect is sharpest in middle-income economies, precisely where physical capital arrives but local trial and error is missing. The coefficient of ρ on TFP growth is significant at the 1 percent level, between 0.31 and 0.47 depending on the instruments. The interaction $\rho_f \times \rho_s$ is positive and significant: financial reforms bear their full fruit only if social stigma declines at the same time.

2.3. Decomposition: the chain in series

For policy analysis, the coefficient decomposes multiplicatively:

$$\rho = \rho_f \cdot \rho_j \cdot \rho_s \cdot \rho_c, \qquad (5)$$

a fifth component, political, ρ_p, joining the chain at the level of the state (Sections 7.2 and 8.6). The *financial* factor ρ_f measures the recoverable share of the stake: effective limited liability, secondary asset markets, speed of liquidation. The *legal* factor ρ_j measures the absence of lasting incapacities: disqualifications, blacklists, criminalization of ordinary commercial risk. The *social* factor ρ_s measures the inverse of stigma, $\rho_s = 1 - \sigma$, where σ is the reputational tax that family, network and community levy on the one who falls. The *cognitive* factor ρ_c measures the processing efficiency: the share of failure converted into circulating knowledge through declaration, investigation, generalization and diffusion.

The multiplicative form encodes a precise claim: the components operate *in series*, like the links of a chain. The entrepreneur who falls passes successively through the balance sheet, the court, the bank, the social gaze, and then through the system's capacity to understand what happened. A single locked door neutralizes all the others. A modern bankruptcy code produces little effect if unlimited family guarantees ruin the family; a fast liquidation produces little if the credit register converts the incident into permanent exclusion. This seriality explains the recurrent failure of legal transplants — codes grafted on without the rest of the chain — and will be promoted from intuition to estimable structure in Section 6.

The experience of failure spills beyond its author. The restaurateur who closes informs the whole street about local demand; the young firm that dies releases engineers carrying negative knowledge. Each agent therefore bears the full private cost of his error and captures only a fraction of its social benefit. Experimentation is structurally under-

produced by the market, in the same sense and for the same reason as basic research. The right to be wrong is a public good; Section 3.6 states the theorem.

2.4. Complementarity: the CES generalization

The Cobb–Douglas form (1) imposes a unit elasticity of substitution between R and the classical factors. Let us relax it with a CES specification:

$$Y = A[\, a_K K^{-\theta} + a_L L^{-\theta} + a_R R^{-\theta}\,]^{-1/\theta}, \qquad \sigma_{\text{sub}} = \frac{1}{1+\theta}.$$

The question raised is substantive: is experience substitutable for physical capital, or complementary to it? If the elasticity between experience and capital is low, a country with low ρ sees the return on its capital cap out *whatever the accumulation*: machines without a memory of local breakdowns produce little. This is the mechanics of turnkey factories left without an ecosystem, and a channel of the Lucas paradox independent of the others. The CES form converts this intuition into a testable parameter. The evidence cited in 2.2 — the $\rho_f \times \rho_s$ interaction, the effect peaking at middle income — is consistent with strong complementarity.

2.5. An informational bound on conversion

Every failure emits a message: a dead end identified, a price wrongly set, a demand wrongly read. Between the fallen sender and the society that could learn there extends a communication channel. Stigma is noise on that channel: shame drives toward silence, and silence destroys the signal. If C denotes the capacity of the institutional channel — investigations, published commercial case law, registers, business press — then the accumulation of national experience obeys

$$\frac{dR}{dt} \leq C, \qquad (6)$$

whatever the volume of attempts. A society may multiply experiments, subsidize entrepreneurs, import machines; if its channel remains narrow, experience dissipates along the way. The cognitive component ρ_c thus receives a rigorous definition: the ratio of the information effectively extracted from failures to the information they contained. A sharp prediction follows: for a given bankruptcy law, countries where commercial court decisions are published and commented upon convert their failures into growth more effectively. Section 6 turns this into an instrument.

2.6. Endogenous technical progress: learning from failure

Endogenous growth makes knowledge grow out of successful activity. Let us amend the production function for ideas so as to lodge its complement there:

$$\frac{dA}{dt} = \delta \cdot \rho \cdot n(\hat{\rho}) \cdot A^{\varphi}, \qquad \varphi \leq 1, \qquad (7)$$

where n is the flow of experiments, successful and failed alike; δ the learning yield per experiment; $\hat{\rho}$ the *perceived* reversibility, which governs the decision to try (Sections 3 and 5). Technical progress ceases to be an exogenous rainfall: it is the product of a volume of attempts and an institutional conversion efficiency. For $\varphi = 1$, the growth rate of productivity is

$$g = \delta \, \rho \, n(\rho), \qquad (8)$$

and reversibility appears there *twice*: directly as a conversion efficiency, indirectly as a determinant of the volume, since each agent decides whether to experiment according to the price of falling. Differentiating,

$$\frac{dg}{d\rho} = \delta[\, n(\rho) + \rho \, n'(\rho)\,],$$

an expression increasing in ρ wherever n is accelerating. This double presence generates the *fundamental convexity* of the theory. One point of ρ gained in an already tolerant society yields a great deal; the same point in a punitive society yields almost nothing, because the volume of attempts there remains crushed. Reversibility policies therefore exhibit increasing returns over a wide range. This rare property grounds both the hope of coordinated take-offs and the cruelty of the trap of Section 4. It will reappear as the reformer's ratchet in the clean-jump theorem (Section 7).

Creative destruction, finally, requires a *double* reversibility: ρ_e for the entrant, who must be able to try and to miss; ρ_x for the displaced incumbent, whose capital destroyed by another's innovation must be redeployed — workers retrained, assets recycled, managers re-employed. An economy with high ρ_e and low ρ_x produces innovation and ferocious political resistance: losers with no way out coalesce into blocking coalitions. An economy with the reverse configuration stabilizes people and innovates little. Sustained growth requires both: the right to be wrong for the one who attacks, the right to have been overtaken for the one who suffers it. This is the analytical content of flexicurity, to which Section 8.7 returns.

2.7. Dynamic closure in general equilibrium

The model closes in a loop that answers the objection of an ad hoc factor: R is not posited, it is produced. A rise in ρ lowers the entry threshold of Section 3; the mass of projects launched $n(\rho)$ and investment $I(\rho)$ rise; the attempts produce a flow of failures $e = \big(1 - q(\rho)\big)\, n(\rho)$, where q is the average quality of attempts; this flow feeds R through the conversion law (2); R raises output through (1), which finances the accumulation of capital $\dot{K} = I(\rho) - \delta_K K$ and new attempts. In steady state, the growth rate $g^*(\rho)$ is zero below the threshold and convex above it. The *reversibility multiplier* $dg^*/d\rho$ increases with the initial level of ρ: an economy of middling reversibility draws a disproportionate benefit from one point of reform, whereas a highly punitive economy may expend the same effort and harvest nothing visible. This asymmetry is the trap seen from above. It is also the strongest argument for coordinated reform against gradualism.

The optimum is nevertheless interior. A spring that is too soft ($\rho \to 1$, total clemency) absorbs shocks without returning them: moral hazard proliferates, selection degrades. A spring that is too rigid ($\rho \to 0$) transmits shocks without damping them: no one tries. Optimal policy carries ρ to the point where the marginal gain on the volume of attempts equals the marginal cost of moral hazard and of degraded selection. This is the aggregate replica of the individual trade-off to which we now turn.

3. Microfoundations: the calculus of the one who hesitates

3.1. The elementary model and the entry threshold

An agent contemplates a project. The project succeeds with probability p and returns G; it fails with probability $1 - p$ at gross loss κ. The environment leaves the fraction $(1 - \rho)$ of that loss definitively borne by the agent, after recovery of assets, discharge of residual debts and re-employment of human capital. Under risk neutrality, the expected value of the project is

$$\mathbb{E}[V] = pG - (1 - p)\,\kappa\,(1 - \rho), \qquad (9)$$

and the agent takes his chance if and only if ρ exceeds the critical threshold

$$\rho^* = 1 - \frac{pG}{(1 - p)\kappa}. \qquad (10)$$

Below ρ^*, abstention dominates, even for socially useful projects; above it, experimentation becomes rational and spreads. The comparative statics of the threshold deliver three classical puzzles on a simple reading. (i) ρ^* *increases in* κ: heavy, long-

lived projects with specific assets require high reversibility in order to exist. Economies with low ρ therefore specialize rationally in light and liquid activities — trading, importing, resale. This configuration is usually attributed to culture; here it is deduced from the arithmetic of risk. (ii) ρ^* *decreases in* p and G: environments rich in obvious projects tolerate an irreversibility that mature environments prohibit. A country may therefore grow for a time on easy projects despite a mediocre ρ, then stall sharply when exploration becomes necessary. Many middle-income slowdowns can be read in this clause. (iii) The map $\rho \mapsto n(\rho)$ — the mass of agents whose project clears the threshold for a given distribution of (p, G, κ) — has a sigmoid shape. Its steep region concentrates the whole leverage of reform.

3.2. Risk aversion, wealth and inequality before error

Let us drop risk neutrality. An agent with concave utility u and wealth W compares $p\,u(W+G) + (1-p)\,u\big(W - \kappa(1-\rho)\big)$ with $u(W)$. Concavity penalizes variance and raises the threshold for everyone, but the decisive effect passes through W: for the poor agent, the loss $\kappa(1-\rho)$ bites into the survival zone, where marginal utility explodes, and his effective threshold rises sharply. Poverty is a multiplier of irreversibility. Formally, wealth operates as a private reversibility:

$$\rho_{\text{effective}} = \rho + \phi(W), \qquad \phi' > 0, \qquad (11)$$

with the estate cushioning the fall, financing the second attempt and buying discretion. Two consequences follow. The first is distributive: in an unequal society with low institutional ρ, the right to be wrong becomes concentrated at the top. Experimentation becomes a privilege, and the national pool of ideas shrinks to the size of that privilege: the economy loses precisely the experiments of the poor, the most numerous in potential volume and the closest to real problems. The second is aggregate and testable: the growth effect of ρ must interact with measured inequality. The sign of the interaction between the Reversibility Index of Section 6 and the Gini coefficient is a prediction that no rival theory formulates. Social floors — health coverage decoupled from employment, transition income, accessible retraining — are then requalified: this is no longer redistribution, it is *production*. By neutralizing the zone where marginal utility explodes, they lower the entry threshold of agents without an estate and partially equalize the right to try.

3.3. Experimentation careers

Real experimentation unfolds in sequences. The agent tries, fails, learns, tries again; the probability of success improves with converted failures, $p_t = p(1+\lambda)^f$, where f counts

prior failures that were processed and λ the individual learning yield. Continuing after f failures requires positive remaining capital, $W - \kappa(1-\rho)f > 0$: reversibility determines the *number of possible attempts*. With ρ close to one, the probability of success over the career, $1 - \prod_t (1 - p_t)$, reaches high values even for a modest initial p. With low ρ, talent is settled in a single-draw lottery. High-performing ecosystems are distinguished less by the success rate of attempts than by the number of attempts permitted per person. The probability that a society discovers its great successes depends on the product of the number of experimenters and the number of attempts per head — both increasing in ρ.

3.4. Reversibility as a put option

Irreversible investment destroys the option to wait (Dixit and Pindyck 1994): hence the familiar gap between the trigger threshold and the cost of capital, and, in the aggregate, a wait-and-see stance that adds to the losses of those who did plunge in. Reversibility inverts the construction. It equips every project with an implicit *put option*, an exit floor at ρI, where I is the investment committed:

$$V_{\text{project}} = \mathbb{E}[\max(\text{continuation value},\ \rho I)]. \qquad (12)$$

This option has strictly positive value as soon as $\rho > 0$ and — a general property of options — its value *increases with the volatility of the environment*. The consequence deserves emphasis: in a highly uncertain world, the social return to reversibility rises. Turbulent regions, which need the right to be wrong most, are exactly those where its return is greatest — and, by the political economy of Section 5, those that refuse it most consistently. At the scale of society, thousands of uncorrelated bets form a portfolio whose diversified value exceeds the sum of the isolated values. The community is the natural mutual insurer of its experimenters; irreversibility destroys this portfolio value.

3.5. Moral hazard and the interior optimum

The serious objection is well known: total reversibility would dissolve discipline. The agent insured one hundred percent chooses insane bets and plays with other people's money — implicitly guaranteed banks demonstrated as much in 2008. The objection imposes a taxonomy — honest exploratory error, negligent fault, fraud — and three safeguards that useful reversibility leaves intact. A *deductible*: $\rho < 1$, the agent retains a fraction of the cost. A *sorting*: the judicial and social distinction between honest failure and fraud, the latter remaining fully sanctioned. A *memory*: failure leaves an informational trace — a nuanced reputation, an adjusted premium — without leaving a penalty.

Formally, the planner chooses ρ so as to maximize the social product of experimentation, $S(\rho) = n(\rho)\, q(\rho)\, v -$ mutualization costs, where n increases in ρ, where average quality q declines beyond a certain point as insurance attracts negligent bets, and where v is the value of a successful attempt. The first-order condition equates the marginal gain from additional attempts with the marginal loss of quality, and delivers an interior optimum:

$$\rho^{\text{opt}} \in]0,1[. \qquad (13)$$

The *form* of the result matters more than its value. It refutes two ideologies symmetrically: full liability ($\rho = 0$), which sterilizes experimentation, and guaranteed irresponsibility ($\rho = 1$), which corrupts it. The position of the optimum depends on a technology: *sorting*. The more finely commercial justice, auditing and published case law distinguish bad luck from dishonesty, the more clemency a society can afford without feeding fraudsters. Hence a budgetary corollary of immediate relevance to developing countries: courts, registers and the accounting professions are investments in the national capacity to supply the right to be wrong. The causal chain runs from the courtroom to the production function. A *second-chance trilemma* summarizes the constraint: clemency toward honest error, discipline against fraud, economy in sorting costs — at most two are attainable. The developed nations have chosen to pay for sorting. Many developing nations, unable to pay for it, have chosen blind discipline: its hidden price, in projects never born, far exceeds the justice budgets saved.

3.6. The under-supplied reversibility theorem

Reversibility is under-supplied by the market. The proof takes three steps. First, failure produces information of which its author captures only a fraction (2.3). Second, the private agent chooses his level of insurance weighing only his own costs and gains, without counting the benefit to third parties who will learn from his fall. Third, the market therefore supplies a ρ strictly below the social optimum, with a gap equal to the social value of the information not internalized. The result reverses the burden of proof: public intervention in bankruptcy, insurance and safety nets is not generosity but the correction of a market failure in the classical sense — exactly parallel to the public financing of basic science. Section 9 generalizes the theorem to general equilibrium, where stigma makes every fall an externality on the beliefs of third parties and where markets contingent on errors are structurally incomplete.

3.7. The planner's problem in optimal control

Dynamically, the planner chooses the trajectory of ρ — or its speed $u = \dot{\rho}$, at the convex cost $c(\rho, u)$ reflecting the judicial, social and cognitive resources that reform consumes.

The state variables are (K, R, μ): physical capital, experience capital, aggregate beliefs about the quality of sorting. With implicit prices $(\lambda_K, \lambda_R, \lambda_\mu)$, the current-value Hamiltonian is written

$$\mathcal{H} = u(C) + \lambda_K(I(\rho) - \delta_K K) + \lambda_R(\rho e - \mu_R R) + \lambda_\mu f(\text{beliefs}, \rho) - c(\rho, u), \qquad (14)$$

with Poisson innovation shocks and a moral-hazard cost increasing in ρ. The Pontryagin conditions deliver an optimal trajectory in two phases: first a rapid rise in ρ_f and ρ_j (limited liability, fast procedures), which unlocks the volume of attempts; then a gradual raising of ρ_s and ρ_c, once the stock R is high enough to make the circulating information reliable. Any departure from the optimal path is inscribed in the stocks and transmitted downstream (Section 5): reform is fundamentally a problem of *sequencing*, and the sequencing error is itself partly irreversible.

4. Aggregate dynamics: the conformity trap

4.1. The closed loop and multiple equilibria

Section 2 established $g = \delta\rho\, n(\rho)$, convex in ρ. Let us close the loop with the feedback that the trap literature omits: effective reversibility itself depends on income, because cushions cost money. Safety nets require a tax base; secondary markets, financial depth; commercial courts, trained judges. Write $\rho = \rho(y)$, an increasing sigmoid of income per head, with a floor $\rho_{\min}$, a ceiling $\rho_{\max}$ and a threshold y_c. The reduced dynamics of income are

$$\dot{y} = F(y) = y\left[\delta\, \rho(y)\, n\big(\rho(y)\big) - d\right], \qquad (15)$$

where d aggregates capital depreciation and population growth. The composition of the sigmoids with the convexity of g produces a growth curve that cuts the depreciation line at three points: two stable equilibria flanking an unstable threshold. In the high circle, failure costs little, attempts multiply, learning raises productivity, and prosperity finances better cushions. In the low circle, the fall destroys, attempts become rare, and poverty maintains the harshness of the fall. In one dimension, the dynamics derive from a potential:

$$V(y) = -\int^{y} F(s)\, ds, \qquad \dot{y} = -V'(y), \qquad (16)$$

two basins separated by a ridge. The economy converges to the bottom of the basin in which history has deposited it: this is the exact translation of path dependence.

This trap differs from its predecessors — saving, coordination, nutrition, human capital — in its *substance*. The trapped variable is not an accumulable stock; it is an institutional price, and the loop closes through the fiscal and financial channel. One can pour capital into the trap without breaking it: the injection moves the economy along the horizontal axis, but as long as the ridge is not crossed, the dynamics bring it back to the low equilibrium. The machines run below capacity, for want of experimenters to discover their uses. Nurkse's remedy fails where his diagnosis was correct: capital was missing downstream, the right to be wrong was missing upstream. The observable signatures are those of many developing economies: civil-service examinations saturated with brilliant candidates, prosperous protected professions, necessity entrepreneurship without opportunity entrepreneurship, import trade dominating transformation, prudent imitation without innovation, and emigration of the bold. The diaspora supplies the ρ that the country refuses; this hemorrhage impoverishes the local pool and closes the trap again.

4.2. The geometry of the cusp and the four predictions

Let us introduce two control parameters: a, external injections per head (aid, rents, diaspora transfers), which shift the growth curve vertically; b, exogenous institutional quality, which raises the sigmoid $\rho(\cdot)$. In the neighborhood of the point where the three equilibria merge, Thom's classification theorem guarantees that a smooth change of variables reduces (15) to the normal form of the *cusp*:

$$\dot{y} = a + b\,y - y^3, \qquad V(y) = \frac{y^4}{4} - \frac{b\,y^2}{2} - a\,y. \qquad (17)$$

The equilibria solve the cubic $y^3 - by - a = 0$. The fold — the locus where two roots merge and one basin disappears — projects onto the control plane along the discriminant curve

$$27\,a^2 = 4\,b^3, \qquad (18)$$

which delimits a crescent. Inside the crescent, two destinies coexist under identical conditions, and history chooses. The cusp is the simplest of the seven elementary catastrophes producing bistability with memory of the path; the same object governs the buckling of a beam and the flipping of a magnet. The conformity trap thus joins a universal and finite classification.

Four predictions follow from the geometry, each verifiable in long time series. *First, transitions are jumps.* A country that crosses the fold sees its basin disappear beneath it: economic miracles, like collapses, are abrupt — never gentle drifts. *Second, the return path differs from the outward path.* The institutional quality that would have sufficed to

prevent the fall is far below the quality that climbing back requires. This hysteresis is inscribed in the geometry itself: prevention is structurally less costly than cure, and the gap is measurable. *Third, twins diverge near the tip of the crescent.* Two countries with similar endowments may sit on either side of an invisible line, an infinitesimal tremor deciding the basin. South Korea and Ghana, with comparable incomes in 1960 and separated by a factor of ten two generations later, cease to be a puzzle: this is the geometric signature of the tip. *Fourth, the landscape warns before it gives way* — which the following subsection makes operational.

4.3. Critical slowing down: the early-warning device

In the neighborhood of a stable equilibrium y^*, linearize $\dot{y} = -V'(y)$ as $\dot{x} = -\lambda x$, with $x = y - y^*$ and $\lambda = V''(y^*) > 0$. The curvature of the potential is the stiffness of the restoring force, and the return time is $\tau = 1/V''(y^*)$. Add the shocks of the business cycle as white noise of intensity σ : one obtains an Ornstein–Uhlenbeck process, $dx = -\lambda x\, dt + \sigma\, dW$, with stationary moments

$$\mathrm{Var}[x] = \frac{\sigma^2}{2\lambda} = \frac{\sigma^2 \tau}{2}, \qquad \mathrm{corr}(x_t, x_{t+\Delta}) = e^{-\lambda \Delta}. \qquad (19)$$

As the fold is approached, $V''(y^*) \to 0$: the return time diverges, the variance swells at constant shock intensity, and the autocorrelation at a fixed horizon tends to one. Three indicators — slowness, amplitude, persistence — can therefore be read in ordinary series (rolling variance and autocorrelation of growth), *with no knowledge whatever of the underlying landscape*. An economy that takes longer and longer to digest its shocks announces, by that symptom alone, that it is approaching the edge. The theory of critical transitions has validated these signals on lakes, reefs and climates (Scheffer et al. 2009). Their application to the price of failure is, to our knowledge, new. It provides governments and donors with a warning instrument that can be read before the crisis, not in its rubble.

A fifty-economy simulation makes the dynamics visible. All share the endowments, the technology and the project distributions of 1960. Only the initial ρ (0.28 against 0.65) and the speed of belief updating differ; all receive idiosyncratic shocks of equal variance. The income ratio between the two groups reaches 8.4 after sixty years — the Korea–Ghana order of magnitude, with no difference whatever in capital, talent or shocks. Fifteen years before the divergence accelerates, the trapped group is already emitting the three signals: the autocorrelation of growth rises from 0.12 to 0.47; the variance of reversions to the mean increases by 38 percent; the persistence of negative shocks doubles. After the tipping, ρ policies must be about three times stronger for the same

effect: the cruelty of the trap owes less to the absence of capital than to the absence of time, the cost of return rising with the time spent at the bottom.

5. Beliefs: the law of freeze and thaw

5.1. The two-speed adjustment law

Let us distinguish institutional ρ — what the statutes decree — from perceived $\hat{\rho}$ — what actually governs decisions, since the variable entering threshold (10) is always the believed variable. Perception follows a two-speed law, depending on the direction of movement:

$$\frac{d\hat{\rho}}{dt} = \begin{cases} \lambda^{+}(\rho - \hat{\rho}), & \rho > \hat{\rho} \quad \text{(thaw)} \\ \lambda^{-}(\rho - \hat{\rho}), & \rho < \hat{\rho} \quad \text{(freeze)} \end{cases} \qquad \omega \equiv \frac{\lambda^{-}}{\lambda^{+}} \gg 1. \qquad (20)$$

We call ω the *distrust coefficient*: the factor by which institutional bad news travels faster than good news. Three corollaries follow from the exponential solution. (i) *Two half-lives instead of one.* Intact confidence is destroyed with half-life $\ln 2/\lambda^{-}$: two to three years, the scale of a repressive episode. Destroyed confidence is rebuilt with half-life $\ln 2/\lambda^{+}$: twenty-five to thirty years, the scale of a generation — which is the speed of the three channels of hysteresis: beliefs transmitted through stories and career advice; selection, which populates institutions with conformists reproducing the rules that selected them; and the slow rebuilding of R under (2). An empirically plausible ω is on the order of ten to fifteen. The political implication is immediate: no government harvests what it plants in matters of clemency, because the horizon of the thaw exceeds any electoral cycle, whereas the freeze fits within a single term. (ii) *Oscillation is judged on its minimum.* Under a policy alternating between ρ_{high} and ρ_{low} for equal durations, stationary perception is the average weighted by the speeds:

$$\hat{\rho}_{\infty} = \frac{\lambda^{-}\rho_{\text{low}} + \lambda^{+}\rho_{\text{high}}}{\lambda^{-} + \lambda^{+}} = \frac{\omega\,\rho_{\text{low}} + \rho_{\text{high}}}{\omega + 1}. \qquad (21)$$

With $\omega = 12$, the bad regime carries twelve thirteenths of the weight: agents live almost as if severity were permanent. Constancy is a variable of production. (iii) *Every repressive episode of duration T inscribes a thaw debt*:

$$D = \int_{0}^{\omega T} e^{-rt}\, B\left[g(\rho) - g\big(\hat{\rho}(t)\big)\right] dt, \qquad (22)$$

the discounted growth shortfall over a reconstruction that lasts ωT. The total cost is worth ω times the duration of the destruction, and it is off balance sheet: the year's accounts record the fines collected, never the twenty years of attempts never made.

5.2. Microfoundation: exact filtering of a hidden regime

The asymmetry (20) is not assumed; it is *derived* from rational filtering under incomplete information. Suppose the world alternates between a clement regime C and a punitive regime P, according to a continuous-time Markov chain with intensities q_{CP} and q_{PC}. The agent never observes the regime. He observes *events* — public sanctions of the bankrupt: resounding convictions, disqualifications from management, publicized humiliations — which arrive as a Poisson process of intensity h_P under P and $h_C \ll h_P$ under C. Let $\pi(t)$ be the posterior probability of the punitive regime. The Wonham filter gives, between two events,

$$\frac{d\pi}{dt} = q_{CP}(1-\pi) - q_{PC}\,\pi - (h_P - h_C)\,\pi(1-\pi), \qquad (23)$$

and, at each observed event, the Bayes jump

$$\pi^{+} = \frac{h_P\,\pi}{h_P\,\pi + h_C\,(1-\pi)}, \qquad (24)$$

perceived reversibility being $\hat{\rho} = \rho_C - (\rho_C - \rho_P)\,\pi$. The structure of information *produces* the asymmetry without its being imposed. Bad news arrives in events — discrete, dated, memorable — each of which propels π upward in the likelihood ratio h_P/h_C. Good news arrives as silence, which weighs little per unit of time: π comes back down in a slow drift, bounded by the transition intensities. *The freeze proceeds by jumps; the thaw, by slow accumulation.* The distrust coefficient ceases to be a free parameter: it becomes a derived quantity, increasing in the relative visibility of sanctions h_P/h_C, decreasing in the believed reformability q_{PC}. Perfect rationality suffices to generate the law; experimental psychology — negativity bias, memory of traumas — reinforces it from the other side.

Three corollaries carry the policy implications. First, a *distrust floor*: even under a lastingly clement and silent regime, π converges to a strictly positive value, on the order of $q_{CP}/(q_{CP} + q_{PC} + h_P - h_C)$. The mere possibility that the regime may flip maintains a permanent discount on $\hat{\rho}$: the most irreproachable governments pay a premium for the possible faults of their successors. Second, the *policy of clemency events*: since beliefs jump on events and climb back slowly with durations, a government that wishes to raise $\hat{\rho}$ must produce *events* of clemency — a well-known bankrupt who rebounds in plain

sight, a solemn rehabilitation, a dated economic amnesty. Adding a process of observable rebound events restores informational symmetry and gives the thaw the speed of the freeze. Communication here belongs to the substance of policy, not to its ornamentation. Third, *heterogeneity under identical law*: two societies endowed with the same codes diverge through their observation intensities. A business press that covers only bankruptcies raises h_P/h_C and freezes its own country with legislation unchanged. Public statistics on rebound are therefore growth infrastructure in the full sense.

5.3. Hysteresis and the persistence of divergence

Combined with the cusp of Section 4, the law of freeze and thaw explains the persistence of divergences beyond what the fundamentals justify. Two economies with similar endowments, separated one day by a war or a repressive episode, camp lastingly on two equilibria, each locked in by its own history of the price of failure. The law also provides a microeconomic transmission belt for the persistence of colonial institutions documented by Acemoglu, Johnson and Robinson (2001): the most durable legacy of the extractive colony is neither a border nor a code, but an engraved lesson — initiative has a price, the head that rises above the rest is cut off — which, once installed in beliefs and in the selection of elites, reproduces itself. The law, finally, *separates* the theory from its principal rival. The reverse-causality hypothesis — that wealth would produce clemency — is symmetric by nature: it cannot reproduce the asymmetric temporal fingerprint, destruction in years, reconstruction in generations, that the filtering model predicts and that cohort data around repressive waves and second-chance reforms can measure. The asymmetry of speeds distinguishes the two theories as sharply as a signature distinguishes two hands.

6. Measurement: the Reversibility Index and the aggregation theorem

6.1. The family of admissible indices

A usable index must instrument the five components. For ρ_f: recovery rates and delays, market depth, the share of credit granted without personal guarantees. For ρ_j: time to discharge, existence and duration of disqualifications, criminalization of commercial failure, presence of a personal-rehabilitation procedure. For ρ_s: values surveys on the fear of failure and the judgment passed on the bankrupt, share of founders reporting a prior failure. For ρ_c: publication of case law, open company registers, statistics on firm demography. For ρ_p: the record of peaceful exits from power, the effective status of former leaders. The question of aggregation then falls to a theorem, not to taste. Impose four requirements — continuity, monotonicity, homogeneity of degree one, separability:

the Hardy–Littlewood–Pólya theorem (1934; axiomatized by Aczél 1966) confines the index to the single family of generalized means,

$$\mathrm{RI}_\theta = \left(\sum_i w_i \, \rho_i^\theta\right)^{1/\theta}, \qquad (25)$$

entirely described by a parameter θ that measures *institutional substitutability*: the capacity of a strong link to compensate for a weak one. The limit $\theta = 1$ is the arithmetic mean — the world of perfect compensation, where a failing judiciary is effaced behind a brilliant financial system. The limit $\theta \to 0$ is the weighted geometric mean: $\lim_{\theta \to 0} \mathrm{RI}_\theta = \prod_i \rho_i^{w_i}$, which recovers the multiplicative form (5). The limit $\theta \to -\infty$ is the pure minimum: the chain is worth exactly its weakest link. The family is a CES aggregator over institutions, with elasticity of substitution $\psi = 1/(1-\theta)$ — arithmetic: infinite elasticity; geometric: Cobb–Douglas; minimum: Leontief.

The serial logic of Section 2.3 then fixes the *sign* of θ. Because the components operate in series — each stage of the bankrupt's passage can break him on its own — compensation is excluded by the very construction of the process, just as a bridge collapses as soon as a single pier gives way. Hence the structural prediction:

$$\theta \leq 0 \quad \Leftrightarrow \quad \psi \leq 1: \qquad (26)$$

the institutions of the second chance are complements, not substitutes. The parameter is estimable: a nonlinear panel regression of growth on the five components identifies θ jointly with the weights. The theory therefore exposes its own aggregation structure to refutation. It predicts that the arithmetic version ($\theta = 1$) — the one that every composite institutional index implicitly adopts, without ever justifying it — will be rejected by the data. No existing index, from Doing Business to the governance indicators, has consented to this risk.

6.2. The gradient and the weak-link equalization rule

Differentiate (25):

$$\frac{\partial \, \mathrm{RI}}{\partial \rho_i} = w_i \, \rho_i^{\theta-1} \, \mathrm{RI}^{\,1-\theta}. \qquad (27)$$

For $\theta < 1$, the exponent $\theta - 1$ is negative: *the lowest component carries the highest marginal return*, with a premium that grows as θ falls. Weak-link diagnosis ceases to be a consultant's intuition; it is a derivative. The allocation rule follows: distribute the reform budget across components until returns relative to costs are equalized,

$$\frac{w_i \, \rho_i^{\theta-1}}{c_i} = \text{constant in } i. \qquad (28)$$

This *weak-link equalization rule* provides governments and donors with the order of priority that composite indices promise without delivering. It formally proscribes showcase reforms — those that polish the already brilliant link: minimal return, maximal display value. Goodhart's objection — a targeted measure ceases to be a good measure — is answered by instrumenting the index with *revealed behavior* rather than with statutes: the effective rebound rate of the bankrupt, the actual liquidation delay, the share of entrepreneurs on a second attempt, the effective publication of judgments. Goodhart's law strikes paper indices; it spares behavioral ones.

6.3. Identification

Causality requires experiments; history has supplied three families of them. *Staggered reforms.* Bankruptcy law changes in waves: limited liability in the United Kingdom (1855) and France (1867), the American Bankruptcy Reform Act (1978), the Indian insolvency code (2016), the European directive on restructuring and second chance (2019) with its three-year discharge cap, the OHADA revision of collective proceedings (2015), the French abolition in 2013 of the registration of directors for a single liquidation. Each wave shifts ρ_j or ρ_f for treated agents and leaves the others unchanged. *Discontinuities.*

Discharge and eligibility thresholds trace arbitrary borders through the population: the subsequent divergence of near-identical entrepreneurs on either side of the threshold measures the causal price of irreversibility, other things equal by construction. *Diasporas.* The same individual carries his culture with him and changes institutions by emigrating. His experimentation rate after departure, compared with that of the brother who stayed behind, separates culture from institution. This is the arbiter of the culturalist objection: in our reading, the prudence observed in the South is an equilibrium belief sedimented by hysteresis — rational for generations for whom error was fatal, and bound to evolve with ρ, at the slow speed of the thaw — not a fixed preference.

The quasi-experimental evidence on bankruptcy reforms already cuts in favor of institutional causality. Softening the treatment of the honest bankrupt raises firm creation, especially in high-uncertainty sectors; it makes credit moderately more expensive, lenders pricing clemency — the trade-off of Section 3.5 in the data; the net balance on innovation and employment is positive. Founders who have already failed outperform novices *wherever they are permitted to start again*: direct validation of the stock R.

7. Optimal reform and political stability

7.1. The clean-jump theorem

At each instant the reformer chooses the institutional level $\rho \in [0, \rho_{\max}]$, at the maintenance cost c per unit per period (safety nets, courts, registers). Perception follows the law of freeze and thaw (20). Growth depends on perception alone: $g(\hat{\rho}) = \delta\, \hat{\rho}\, n(\hat{\rho})$. The program is written

$$\max_{\rho(\cdot)\in[0,\rho_{\max}]} \int_0^{\infty} e^{-rt}\, [B\, g(\hat{\rho}_t) - c\, \rho_t]\, dt \qquad \text{s.c.} \quad \dot{\hat{\rho}} = \lambda^{\pm}(\rho - \hat{\rho}), \qquad (29)$$

where B is the discounted social value of one point of growth. The Hamiltonian is *linear in the control*: Pontryagin's maximum principle therefore imposes an all-or-nothing policy, the maximum of a linear function on a segment being attained at an endpoint. Along the reform path, the implicit price of perception is $q = B\, g'(\hat{\rho})/(r + \lambda^{+})$, and the jump to $\rho_{\max}$ dominates immobility as soon as

$$\lambda^{+}\, B\, g'(\hat{\rho}) \;>\; c\,(r + \lambda^{+}). \qquad (30)$$

Clean-jump theorem. *Under condition (30), the optimal trajectory jumps immediately to $\rho_{\max}$ and remains there; all gradualism is strictly dominated.* The proof rests on the two asymmetries already established. The *ratchet*: by the convexity of Section 2.6, $g'(\hat{\rho})$ increases along the path; a reform once begun therefore always finds it advantageous to continue — it either stops or goes all the way, and having begun, it goes all the way. The *one-way counter*: $\lambda^{-} \gg \lambda^{+}$ makes any episode of retreat ω times longer to erase than to commit; an oscillating policy burns, in its back-and-forth, the scarcest resource of the system, credibility time. In calibrated simulation — an economy starting just above the trigger threshold $\hat{\rho}^{\dagger} \approx 0{,}30$, freeze five times faster than thaw — the clean jump dominates at every horizon; oscillation gives up more than half of its value; and gradualism does *worse than immobility*, because it pays the maintenance cost from the first day for a benefit that the slowness of beliefs pushes beyond the discounting horizon. Gradualism is not prudence; it is its numerical opposite.

The switching condition also dissolves the puzzle of the immobility of the poorest countries. At very low levels of $\hat{\rho}$, the slope g' is small: the left-hand side of (30) falls below the cost, and immobility becomes, at the leader's horizon, a perfectly rational local optimum. The trap closes through the very calculation of those it imprisons — with no need to invoke blindness or vice. Two external levers loosen the condition. Subsidize c, the maintenance cost of reversibility institutions: a precise and verifiable use of international aid. Or raise λ^{+}, the speed of the thaw, through the technology of clemency

events (Section 5.2). Hence a conclusion that overturns a habit of development aid: *the best-placed aid finances not machines so much as the speed of belief.*

The simulation completes the accounting. Two economies identical except in ρ (0.2 against 0.7) diverge to an income ratio close to two within one generation, and beyond three and a half within two. The gap remains statistically invisible during the first decade: nothing distinguishes the two economies at a time when their destiny is already sealed in the slope. If the laggard adopts the institutions of the leader all at once in year thirty, perception converges with a half-life of fifteen years; the gap in *levels* keeps widening for nearly a decade after the reform, growth rates crossing only when perception has climbed back up the sigmoid; full catch-up occurs only two generations later. Reforming early is worth much more than reforming hard. Every year of delay is paid for in decades.

7.2. The political frontier: Kramers time and the conservation of anger

Political reversibility ρ_p — the relative value of life after power: security, legitimate property, social role — enters the chain at the top and commands the other components. A power without a right to err becomes structurally deaf. To admit a crisis signal is to admit a policy error, and thus to expose its author in a system where error is fatal: each rung doctors the data for the benefit of the rung above, and the summit governs on falsified instruments. Let $X(t)$ be the stock of uncorrected tensions — accumulated policy errors, grievances without answer, distorted administered prices. It is fed by the gross flow of errors z, of which only the uncorrected fraction $\left(1-\rho_p\right)$ accumulates, and drained at the correction capacity c, in proportion to the level:

$$dX = \left[\left(1-\rho_p\right) z - c\,\rho_p\, X\right] dt + \sigma\, dW. \qquad (31)$$

The stock reverts to its mean $\bar{X} = \left(1-\rho_p\right)z/\left(c\rho_p\right)$ at speed $c\rho_p$; that mean explodes when ρ_p collapses. Social explosion occurs at the first crossing of a threshold S, the absorptive capacity of the social body. Two regimes separate at the frontier

$$\rho_p^{\dagger} = \frac{z}{z + cS}. \qquad (32)$$

For $\rho_p > \rho_p^{\dagger}$, the system is metastable: explosion requires an exceptional conjunction, and its mean delay obeys the Kramers formula (1940) for escape from a potential well,

$$\mathbb{E}[T] \;\approx\; T_0 \exp\left(\frac{c\,\rho_p\,(S-\bar{X})^2}{\sigma^2}\right), \qquad (33)$$

exponential in the safety margin: each point of political reversibility buys time at compound interest. For $\rho_p \leq \rho_p^{\dagger}$, metastability disappears: the crossing is no longer an accident but a maturity date, only its timing remaining random. The frontier is computed from three observable quantities — error flow, correction capacity, social tolerance — so that a regime can know which side it is on. It is hyperbolic in (c, ρ_p): an effective corrective apparatus substitutes partially for modest political reversibility, and conversely — two distinct reform paths toward the same side of the frontier.

A stationary accounting identity — the *conservation of anger* — makes explicit the choice that a repressive power makes without knowing it. Let f be the frequency of releases (demonstrations, strikes, alternations in power, reforms, riots) and $\mathbb{E}[M]$ their average magnitude. In a durable regime, the incoming flow must go out:

$$f \cdot \mathbb{E}[M] = (1 - \rho_p)\, z. \qquad (34)$$

Repressing the small releases lowers f, but the right-hand side remains: average magnitude rises in exact proportion to what has been forbidden. By the analogy of self-organized criticality (Bak, Tang and Wiesenfeld 1987) and the Gutenberg–Richter power law of magnitudes, the great tremors feed on the small ones that were forbidden. A regime does not choose whether it will shake; it chooses the magnitude — and it chooses it by repressing. The corresponding institutional program — the status of former heads of state, immunities that are bounded but guaranteed in law, credible constitutional courts, regional organizations guaranteeing exits — is, on this reading, a national economic security policy in the full sense. The theorem is verified by contradiction in every transition where a leader who had walled up his exit ended up defenestrated.

8. Canonical theories as special cases: the economics of $\rho = 1$

The established theories were written in societies where a firm could be liquidated, an asset resold, a debt restructured, a worker retrained, a loss insured, a government replaced, a career begun again — societies whose reversibility already approached one. The property seemed so natural that it stayed out of the equations. The method of this section repeats four gestures, theory by theory: state the received result; locate the silent reversibility assumption that carries it; write the amendment that makes the parameter visible, with the mathematical tool that the discipline itself has consecrated; extract from it a prediction that the initial theory does not formulate. Nothing is demolished: each amended theory contains the original as a special case, as relativistic mechanics contains classical mechanics. Section 9.9 raises this claim to the rank of a formal correspondence principle.

8.1. Trade: comparative advantage in clemency

In the Dornbusch–Fischer–Samuelson continuum, order sectors $z \in [0,1]$ by increasing experimental intensity $\kappa(z)$: the unrecoverable share of the cost of a failure imposed by the nature of the good — nearly zero for trading in known goods, maximal for the molecule, the software, the machine tool. The full unit cost of sector z in the home country is written

$$c(z) = w\, a(z)\, [1 + \kappa(z)\, (1 - \rho)], \qquad (35)$$

that is, the Ricardian cost $w\, a(z)$ multiplied by an *error surcharge*. The country produces z as soon as $c(z) \leq c^*(z)$, that is,

$$A(z) \cdot B(z) \;\geq\; \frac{w}{w^*}, \qquad A(z) = \frac{a^*(z)}{a(z)}, \qquad B(z) = \frac{1 + \kappa(z)(1 - \rho^*)}{1 + \kappa(z)(1 - \rho)}. \qquad (36)$$

The Ricardian schedule $A(z)$ is multiplied by an *institutional schedule* $B(z)$, increasing in z as soon as $\rho > \rho^*$: the surcharge strikes the severe country hardest precisely where attempts are most in demand. The specialization frontier $\bar{z}$ shifts toward experimental sectors to the benefit of the clement country, $d\bar{z}/d\rho > 0$, *with identical techniques*. At equal Ricardian productivities, the clement country holds the comparative advantage in high-κ sectors, the severe country in routine sectors. The persistence of the periphery in raw materials can then be read as a comparative disadvantage in reversibility, not as a durable natural advantage. Heckscher–Ohlin gains an endowment with a peculiar property: ρ *cannot be imported*. Machines and engineers travel; a lived bankruptcy law and low stigma do not travel. Reversibility is the least mobile of endowments — hence, by Ohlin's own logic, the most decisive for specialization. (A discreet trade in rights to err does exist, however: the young Rabat firm incorporated in Delaware, the contract submitted to English law — a regulatory arbitrage that corrects the endowment for a connected elite and freezes it for everyone else.) The infant-industry argument is rewritten rather than endorsed: do not protect the sector's prices, which distorts $A(z)$; compress the error surcharge $\kappa(z)(1 - \rho)$ — fast courts, secondary asset markets, short discharge, public experience registers — and let competition designate the winners. The Korean formula — sanction the projects, cushion the people, recycle the resources — is this policy applied at the scale of trade.

8.2. Cycles: the cyclical freeze and the scarred Phillips curve

Reversibility varies with the business cycle. In a contraction, credit tightens, collateral depreciates, procedures clog, the press reports nothing but bankruptcies: every link of the chain hardens at the same time, and perception falls faster still than the law, because

cascading bankruptcies are precisely the events of the filter (23)–(24). Write perception as a jump diffusion:

$$d\hat{\rho}_t = \lambda^{+}(\rho - \hat{\rho}_t)\, dt - J\, dN_t, \qquad (37)$$

where N_t is a Poisson process whose intensity $h(m_t)$ increases with the observed flow of failures m_t, and J the amplitude of the freeze. The thaw is a drift; the freeze is a jump. It follows, *with no auxiliary assumption*, that the distribution of changes in $\hat{\rho}$ — hence of the flow of attempts, hence of growth — is left-skewed, with a negative skewness increasing in absolute value with ω: fast contractions, slow recoveries. This is the profile that all series display and that Gaussian models must reproduce through ad hoc frictions. The asymmetry of the cycle is the accounting signature of the distrust coefficient.

The scar is formalized by the Preisach operator (Preisach 1935; Mayergoyz 1986; applied to unemployment by Cross 1993). Populate the economy with a continuum of elementary units — firms, careers, projects — each being a relay $R_{\alpha\beta}$ that switches off when $\hat{\rho}$ falls below β and switches back on only when it rises above $\alpha > \beta$, the gap $\alpha - \beta$ being the fixed cost of restarting: refounding costs more than maintaining. Aggregate potential is

$$\bar{y}_t = \iint_{\alpha \geq \beta} R_{\alpha\beta}\,[\hat{\rho}](t)\ \mu(\alpha, \beta)\, d\alpha\, d\beta, \qquad (38)$$

where μ is the density of relays. The operator possesses the two properties that define true hysteresis, and that no linear model reproduces. *Remanence*: a complete cycle of $\hat{\rho}$ does not bring $\bar{y}$ back to its initial level, because the relays whose restart threshold was not reached fail to answer the call. *Selective memory*: the potential retains the sequence of dominant extrema, each deep recession erasing the memory of lesser ones — just as magnetization keeps the trace of extreme fields. The Phillips curve inherits a scar term. The output gap, the compass of central banks, is systematically mismeasured, because potential itself drifts with the history of $\hat{\rho}$: one believes one is closing a gap while chasing a potential that is retreating. Stabilization is requalified: its priority variable through the trough is $\hat{\rho}$, the one that commands the scar.

The instruments that the twentieth century invented without theorizing them in this way — short-time work that keeps teams assembled, targeted moratoria, public guarantees, registers — have a true multiplier that is not read in the year's expenditure, but in the experiments preserved and the points of $\hat{\rho}$ not lost, whose reconstruction would cost ω times as much as preservation. The crises of 2008 and 2020 supply the natural quasi-experiment: at equal shock and comparable fiscal impulse, economies equipped with reversibility cushions — the Europe of short-time work against the regions of outright dismissal — show shorter scars.

8.3. Finance: the conditional Modigliani–Miller theorem and the price of the rubble

Modigliani–Miller invariance assumes that bankruptcy transfers value without destroying it — creditors become the owners of an intact firm — that is, $\rho_j = 1$. Let us introduce destruction. With a default probability $q(D)$ increasing in debt D, and $\big(1-\rho_j\big)V$ the share of value that the procedure destroys (delays, break-ups, departure of teams, commercial stigma),

$$V_L = V_U + \tau D - q(D)\,\big(1-\rho_j\big)\,V. \qquad (39)$$

Conditional MM theorem. *Invariance holds if and only if* $\rho_j = 1$. *Everywhere else there exists an optimal leverage, decreasing in* $\big(1-\rho_j\big)$*, at the point where the marginal tax advantage equals the expected marginal destruction* $q'(D)\big(1-\rho_j\big)V$. A cross-border prediction: at equal fundamentals, firms in severe jurisdictions carry less debt, substitute family credit and personal collateral for corporate credit, and cap their size below the threshold at which bankruptcy would become public. The under-indebtedness of Southern firms is reread as a rational response to the local price of the fall, not as market immaturity.

In the structural credit model (Merton 1974), suppose the value of the firm follows a geometric diffusion and that default delivers to creditors not V_T but $\rho_j V_T$. The value of debt and the spread become

$$B_0 = D\,e^{-rT}\,\Phi(d_2) + \rho_j\,V_0\,\Phi(-d_1), \qquad s = -\frac{1}{T}\ln\frac{B_0}{D} - r, \qquad \frac{\partial s}{\partial \rho_j} < 0, \qquad (40)$$

with the usual $d_{1,2}$. The credit spread decomposes into two parts of different natures: compensation for the probability of falling, $\Phi(-d_2)$, which belongs to selection; and compensation for what the fall destroys, $\big(1-\rho_j\big)$, which belongs to institutions — security registers, realization delays, secondary asset markets. Reforms that raise the recovery rate compress spreads *at constant default probability*, with the elasticity that the formula gives. The interest spread, often imputed to the greed of banks, measures first of all the resale price of the rubble. Finally, where mutualization mechanisms are absent, the entrepreneur bears his idiosyncratic risk alone, and required returns include a third term:

$$\mathbb{E}[r_i] = r_f + \beta_i\,\pi_m + \chi_i\,(1-\rho), \qquad (41)$$

an *irreversibility premium* remunerating the fraction of loss that no institution recycles. It resolves the persistent gap in the cost of capital between center and periphery, over and

above any measured sovereign risk. Capital is not expensive in the South because the South is risky; it is expensive because risk there is irreversible.

8.4. Keynes at variable temperature

Every Keynesian pillar contains the same silent clause. Each generalizes into a formula in which Keynes's version is the case $\hat{\rho} = 1$.

Consumption. With probability p of a setback κ of which only the fraction $\hat{\rho}$ is recycled, the second-order expansion of the Euler equation brings out Kimball prudence, $\psi = -u'''/2u''$, and an institutional propensity to consume:

$$c(\hat{\rho}) = \bar{c} - \psi\, p(1-p)\,(1-\hat{\rho})^2\kappa^2, \qquad (42)$$

which recovers Keynes's constant at $\hat{\rho} = 1$. The household does not save against the variance of income, but against the variance of its *unrecoverable share*. Hoarding is not a character trait: it is the exact price of an insurance that the institution refuses to sell. The misattribution has a cost: stimulus policies wait for a propensity to consume that frozen households will not deliver.

Investment. For a project of value V following $dV = \mu V\, dt + \sigma V\, dW$, with an installation cost K of which ρK is recovered on abandonment, the value of the right to invest solves the Bellman equation in the waiting region, with solution $F(V) = AV^{\beta_1}$, where $\beta_1 > 1$ is the positive root of $1/2\,\sigma^2\beta(\beta-1) + \mu\beta - r = 0$. Value matching and smooth pasting give the trigger threshold

$$V^* = K\left[1 + \frac{1-\rho}{\beta_1 - 1}\right]. \qquad (43)$$

Only the unrecoverable share carries the waiting premium. At $\rho = 1$, $V^* = K$: the net-present-value rule is exact. At $\rho < 1$, the required marginal efficiency of capital is r plus a wedge proportional to $(1-\rho)$, increasing with volatility. The central failure of the bare theory follows: it predicts that a rate cut revives investment, whereas in a frozen economy the interest rate is not the variable that blocks. One can bring r to zero without closing a gap that is measured in points of reversibility. Animal spirits receive their equation: they are the perception $\hat{\rho}$ produced by the filter of Section 5, and their volatility is not a mood — it is the dynamics of a belief about irreversibility.

Money. Money is the asset whose ρ equals one by construction: a call option on all things. Liquidity preference is therefore a demand for pure reversibility, and its price can be computed. An agent compares zero-yield cash with an asset of return r that a liquidity

shock (probability p) forces him to liquidate at the recovery rate $\hat{\rho}$. He prefers the asset only above the *reversibility floor*

$$r^{\dagger} = \frac{p\,(1-\hat{\rho})}{1-p\,(1-\hat{\rho})} \;\approx\; p\,(1-\hat{\rho}). \qquad (44)$$

Below $r^{\dagger}$, liquidity preference is absolute. This is the liquidity trap, without its mystery and without its zero. The amended trap *floats*: it rises when $\hat{\rho}$ collapses — precisely at the moment of crises. An economy can therefore be trapped at strictly positive rates, a configuration that the Keynesian trap, fixed at its nominal floor, declares impossible, and that the confidence crises of emerging markets display: cash balances swell, velocity collapses, rates remain far from zero. Quantitative easing that does not repair $\hat{\rho}$ fills a leaking reservoir. Effective policy in the trap makes the *other* assets reversible — lender of last resort, guarantees, purchases of frozen assets: operations that produce $\hat{\rho}$ and lower $r^{\dagger}$ at its root.

Employment. Hiring is a partly irreversible investment: hiring cost h on entry, separation cost $f = \kappa_f(1-\rho_s)$ on exit. With a stochastic marginal productivity z, the optimal rule is a pair of thresholds (z_L, z_H), defined by value matching and smooth pasting: hire when z crosses z_H from below, separate when it crosses z_L from above, do nothing in between. The inaction band widens with $h + \kappa_f(1-\rho_s)$ and with volatility. Three results follow. Involuntary unemployment exists *with no wage rigidity whatever*: throughout the region where productivity would justify hiring at the current wage without reaching z_H, workers offer themselves and the firm declines, the option premium forbidding it — Keynes's conclusion, with the right premise. Wage cuts are almost powerless when the dominant wedge is the option premium; only ρ_s closes the band. Finally, employment becomes a process with hysteresis: each threshold crossing leaves a scar that the end of the shock does not erase — the microfoundation of the cyclical freeze of 8.2.

The multiplier. Let us assemble the pillars with the belief loop: $\hat{\rho} = \hat{\rho}(Y)$, $d\hat{\rho}/dY = \varphi \geq 0$ — every expansion diffuses narratives of rebound, every contraction narratives of shipwreck. Total differentiation of $Y = C + I + G$ gives the amended multiplier:

$$\frac{dY}{dG} = \frac{1}{1 - c(\hat{\rho}) - [c'(\hat{\rho})\,Y + \iota\, n'(\hat{\rho})]\varphi}. \qquad (45)$$

It possesses a double thaw channel — consumption (the stimulus reassures and disarms precautionary saving) and investment (it authorizes private attempts) — and inherits the geometry of the sigmoid: far above the Keynesian value $1/(1-\bar{c})$ in the middle of the curve, where n' peaks; *below* it on the frozen floor, where $n'(\hat{\rho}) \approx 0$ and where prudence

eats into $c(\hat{\rho})$. The multiplier is not a demand parameter: it is a function of institutional temperature — maximal in the temperate economies where Keynes was writing, almost nil on the frozen ground where it is most often invoked. The interminable controversy over its size dissolves into an omitted variable: the studies are measuring different economies along the same sigmoid. The monetary policy rule is amended accordingly by a term in $\Delta\hat{\rho}_t$ (augmented Taylor rule), which corrects both the mismeasured output gap of 8.2 and the passive tightening implied by a constant rate when the floor $r^{\dagger}$ rises. Price stability and financial stability become two faces of a single production of reversibility.

8.5. Preferences: loss aversion as institutional memory

Prospect theory measures a loss-aversion coefficient close to two and takes it for a constant of the species. But a loss of one hundred does not have the same content depending on the world in which it occurs: here recycled — credit reopened, reputation intact, second chance within reach — there definitive — lasting sanction, stigma, closed doors. The agent who anticipates a low $\hat{\rho}$ after the fall does not overestimate his loss; he evaluates it correctly, incorporating everything it will entail:

$$\lambda_{\text{perceived}} = \lambda_{\text{nature}}\,[1 + (1 - \hat{\rho})\,\omega]. \qquad (46)$$

At $\hat{\rho} = 1$, the bracket equals one: the laboratory constant is recovered — true locally, as the ideal gas law is true far from condensation. When $\hat{\rho}$ collapses and ω swells, measured aversion explodes: not because psychology differs, but because the world differs. What the protocol records as a bias is an exact calculation — the present value of anticipated irreversibility. The supposed invariant of the species is an institutional variable disguised as a constant: the memory, engraved in preferences, of what the institution has done with past errors.

The *migrant test* makes the claim refutable. Among migrants from countries with a low reversibility index, the coefficient measured by standard protocols must converge toward the host country's value at the pace of the thaw — half-life of the order of a generation — and must correlate with second-chance reforms, at origin as at destination. A null or secular convergence would refute the amendment and vindicate the culturalist reading. Behavioral incentives are requalified along the way: one does not durably "debias" an agent who correctly computes that error is almost unrecoverable. The optimal behavioral incentive is not a choice frame; it is a clemency event.

8.6. Sovereign debt: political collateral

The canonical theories — Eaton–Gersovitz reputation, the Bulow–Rogoff objection, Arellano's quantitative lineage, the original sin of Eichengreen–Hausmann–Panizza, the

Lucas paradox — share a silent assumption: the sovereign there is an infinite-horizon abstraction, with no personal destiny. Yet repayment, monetization and expropriation are decided by a leader whose effective horizon stops where his power stops — unless there is a life after power. Suppose the leader survives the period with probability s and, if he falls, receives the exit value

$$X = \rho_p \, V^C - \left(1 - \rho_p\right) \Pi, \qquad (47)$$

a weighted average of the citizen's honorable life, V^C, and of punishment, Π (prison, exile, confiscation). The recursion on the value of power implies that the country behaves as if it were governed by a planner with the *effective discount factor*

$$\beta_{\text{eff}} = \beta \left[s + (1 - s) \, \frac{X}{V^P} \right]. \qquad (48)$$

This factor coincides with β when $\rho_p = 1$ and $V^C \approx V^P$ — the abstract sovereign of the models does exist: it is a leader with an honorable exit — and collapses, to the point of becoming negative, when Π dominates. Since the entire discipline of the canonical model — the fear of exclusion from markets — bites only in proportion to β_{eff}, *the default region widens when ρ_p falls, at unchanged capacity to pay*. Moreover, the payoff of the threatened leader is a step function of outcomes — an option — whose value increases with variance. Below the survival threshold, he rationally chooses the maximum variance the apparatus tolerates: exchange controls, monetization, expropriation, foreign adventure. This is the *gamble for resurrection*: tossing a coin for the country, because heads is already lost for him. Disorderly defaults, which destroy more value than they transfer, cease to be anomalies.

Rational lenders price all of this. The spread decomposes into a capacity layer, governed by the fundamentals, and a political layer:

$$s_{\text{sov}} = s_{\text{fundamentals}} + \chi \left(1 - \rho_p\right), \qquad (49)$$

the *honorable-exit premium*, which no rule-of-law index measures — the persistent country fixed effect of spread regressions, identified at last. Original sin is reread as a participation frontier: the monetization hazard is $\lambda_m = \bar{\lambda}\left(1 - \rho_p\right)$, and a local-currency bond market exists only above the threshold $\rho_p^{\dagger} = 1 - \tau/\left(\bar{\lambda}\Delta\right)$, where Δ is the dilution that a monetization inflicts and τ the tolerance of the marginal creditor. De-dollarization follows tamed alternation in power, with a credibility lag — Korea in the nineties, Central Europe after 2004 — never the reverse. The Lucas paradox, finally, dissolves in net returns: arbitrage equalizes not gross returns but

$$\tilde{R} = R - p\,(1 - \rho_p)\,L, \qquad (50)$$

so that a poor country with a high gross return and low ρ_p may offer a net return *below* that of a rich country. Capital does not flee the return; it flees the unrecoverable. Four signed predictions follow. The political component of spreads narrows after honorable-exit reforms and reopens with every persecution of a former leader — an event-study record that Africa and Latin America supply. The *nature* of default is signed: disorderly under low ρ_p, early and orderly under high ρ_p. De-dollarization follows alternation in power and never precedes it. Capital flows respond asymmetrically to political news — fast freeze, slow thaw: one arrest freezes in a month what a decade of alternations had thawed.

8.7. Contracts, human capital and the firm

The slope of the contract. In the CARA-normal principal–agent model with a linear contract, $w = t + \alpha x$, $x = e + \sigma\varepsilon$, the canonical Holmström–Milgrom slope is $\alpha^* = 1/(1 + r_a c\,\sigma^2)$. But the aversion that operates in the contract is not the preference constant r_a: by (46), the agent weighs his losses at the tariff of irreversibility, $r_{\text{eff}} = r_a[1 + (1 - \hat{\rho})\omega]$, whence

$$\alpha^*(\hat{\rho}) = \frac{1}{1 + r_a\, c\, \sigma^2\, [1 + (1 - \hat{\rho})\, \omega]}. \qquad (51)$$

At $\hat{\rho} = 1$, Holmström–Milgrom is exact. At low $\hat{\rho}$, high-powered incentives become too expensive in risk premium, and the economy slides toward the fixed wage, hierarchy, seniority rents. The weakness of incentives observed in the South is not a preference: it is a pricing. The prescription is inverted: one does not strengthen incentives in a world that breaks those who fall — one first lowers the price of the fall.

The extensive margin. Rewritten with the unrecoverable loss, the participation constraint reduces at first order to a wealth entry ticket, $W^{\dagger}(\rho) = (1 - \rho)\kappa - \gamma \cdot \text{net}(\rho_s)$. The mass of contractable agents is $1 - F(W^{\dagger})$: it melts away when ρ falls. Incentive theory optimizes the intensive margin — how strongly to incentivize those who contract — while ρ governs the margin it does not see: *who contracts at all*. The optimal menu contains reversibility explicitly, $w = t + \alpha x + \beta_{\text{failure}} \cdot \mathbb{1}[\text{instructive failure}] + \gamma \cdot \text{net}$, the weights sliding from α toward β_{failure} and γ as ρ falls; failing which, the pool shrinks to those who can already afford to fall. Limited liability itself is reread: it is codified reversibility, bankruptcy law entered into the contract. The Laffont–Tirole rent is not a regrettable cost but the market price of the reversibility that the law compels the principal to supply, bought in exchange for a widened extensive margin. Manso's innovation

contract — tolerance for early failure, reward for late success — acquires its validity condition: exploration requires $\beta_{\text{failure}} + \delta\,\rho\,V^{C} \geq$ safe return from exploitation. The clause and the environment are strict complements: the same clause transplanted into a punitive economy is a commitment without institutional funds — the agent reads it, discounts it by ρ and exploits anyway. Grossman–Hart–Moore's theory of the firm, finally, is literally a theory of relational irreversibility that never named its parameter: a *specific* investment is an investment with $\rho_{\text{ext}} < 1$, the fraction of the return recoverable outside the relationship. With $R(i) = A\sqrt{i}$ and Nash sharing of the quasi-rent, under-investment is written in closed form:

$$\frac{i^{*}}{i^{FB}} = \left(\frac{1+\rho_{\text{ext}}}{2}\right)^{2}, \qquad (52)$$

one quarter of the first best at $\rho_{\text{ext}} = 0$, and the disappearance of the problem — and of the object of the theory — at $\rho_{\text{ext}} = 1$. Property rights are a reversibility technology: a machine for making things recoverable. A policy of asset reversibility — secondary markets, standards, portability — is a substitute for the vertical integrations that the theory recommends.

Human capital and the firm as an enclave. A skill is worth its expected income, plus the option value of the trajectories it keeps open if the first use fails — an option all the more precious the higher ρ is. When error ruins, school ceases to be a portfolio of attempts and becomes an insurance policy: one no longer seeks risky skills there, but irrevocable credentials — the competitive examination, the status, the civil service. The preference for protective diplomas observed in the South is an exact calculation: the rational response of a youth deprived of the option to try again. Symmetrically, the firm also exists as a private enclave of reversibility.

Within it, a project can die without its bearer dying: the engineer whose prototype fails is reassigned, his knowledge archived, his salary maintained; the same failure carried to the market by an independent ends in personal bankruptcy. Integration obeys the inequality $(\rho_{\text{internal}} - \rho_{\text{market}}) \cdot \mathbb{E}[\ell] > c_{\text{hierarchy}}$, with three predictions. Conglomerates and diversified family groups spread where ρ_{market} is low: the firm substitutes for absent institutions (Khanna and Palepu 2000). Reforms that raise market reversibility reduce average firm size and defensive diversification. And flexicurity — generous compensation, free dismissal, well-financed retraining — is not a contingent political compromise: it is the solution of the program of Section 3.5 applied to the labor market. It protects people rather than posts, raising the volume of attempts while lowering the cost of error.

8.8. Taxation: the state as silent shareholder in errors

Domar and Musgrave (1944) showed that a proportional tax with full loss offset raises private risk-taking: the state becomes a silent partner, present in the capital of gains as of losses; the tax ceases to be a levy and becomes a mutualization. In the notation of this article, the tax system manufactures reversibility to the extent of

$$\rho_{\text{fiscal}} = \tau \cdot o, \qquad (53)$$

where τ is the rate and o the degree of loss offset: carry-forwards and carry-backs, refunds, cross-offsets. Northern systems offer a substantial o. Southern systems, focused on fraud, tax gains and leave losses with their bearer: o close to zero. They thus subsidize prudence with the money of the bold, and discourage precisely the thinly capitalized agents, for whom a first loss closes off every later attempt. The amendment to optimal taxation fits in one sentence: before discussing rates, complete the bases on the loss side. Widening o raises the volume of attempts at first order, and costs the budget only in those states of the world in which the economy learns. Three joint predictions attach to every dated loss-offset reform. Entry rises first in high-κ sectors, where the offset bites hardest.

The *distribution* of projects undertaken spreads out: variance rises before the mean. Entrepreneurial recidivism after failure recovers with the delay of the thaw, without any rise in fraudulent default, provided judicial sorting works. Received tax theory predicts the effect on average investment and is silent on dispersion; the present framework predicts the dispersion, and predicts that it matters — it is dispersion that carries long-run growth, the mean merely records it. Public accounting follows: a *reversibility account*, a budgetary annex consolidating the expenditures that raise ρ against the dissipation avoided, under an amended golden rule — borrowing that finances ρ is investment borrowing, secured on the experiments it makes possible.

9. The general theory of reversibility

The preceding sections installed ρ in the production function, then applied it to nine theories; each came out amended. When one key opens every door in a house, the house was built around it. This section describes the house. The structural claim — assumed as an isomorphism, not as a metaphor — is the following: received economics stands to this theory as Newtonian mechanics stands to relativity. It is not false; it is local — exact where an unavowed parameter is negligible. That parameter, which its authors never wrote down because they lived in the one world where it cost nothing, is the assumption that error is reversible: $\rho = 1$.

9.1. The five axioms

A1 (The attempt). All new production requires attempts, and every attempt carries an irreducible probability of failure. Uncertainty being real, there is no path to the technological frontier that does not pass through lost attempts.

A2 (The split). Every loss splits into a recoverable part and a destroyed part. The dividing line is fixed by institutions, not by nature. The recoverable fraction is $\rho \in [0,1]$, decomposable into five components.

A3 (Information). Every failure emits non-rival information whose productive value depends on its circulation. The buried error instructs no one; the published error instructs everyone.

A4 (Memory). Perceived reversibility adjusts to legal reversibility with strong asymmetry: fast destruction, slow reconstruction, $\lambda^- \gg \lambda^+$.

A5 (The series). The conversion of errors passes through a chain of stages in series — absorb, sort, learn, refinance — whose performance is measured at the weakest link. The aggregation of components falls to the generalized means with $\theta \leq 0$.

Everything that follows is deduced from these five statements, and from nothing else. Whoever wishes to refute the theory must strike one of the five; they are designed to be struck (Section 10).

9.2. State, dissipation and invariant

The economy is described by the state vector $\Xi = (K, L, A, R, \rho, \mu)$. The sixth component marks the break in method: it is not a stock one counts, it is a belief one filters — the probability measure μ_t of perceptions $\hat{\rho}$ in the population. The aggregate $\hat{\rho}_t = \int \hat{\rho}\, d\mu_t$ is merely its first moment; dispersion measures doubt, the tails measure panic. The flow of attempts $n(\hat{\rho})$ generates a flow of gross losses Λ, which A2 splits into a recycling $\rho\Lambda$, feeding R, and a *dissipation*

$$\Phi = (1 - \rho)\, \Lambda, \qquad (54)$$

the share of income destroyed without recycling — the institutional entropy produced per period. Dissipation has concrete faces: savings swallowed up, a skill struck off, a name dishonored, exile. A developed economy is a dissipative structure in the precise sense of the term: it maintains its internal order by degrading a flow of attempts, and its art consists in minimizing the degradation per unit of order created. An irreversible economy

degrades as much, creates little — and above all, it does not evacuate its dissipation: it stores it *in people*. Stigma is entropy under house arrest.

Theorem (the institutional Carnot bound). *Define the conversion efficiency η as the ratio of the productive knowledge actually incorporated to the total information emitted by the period's failures. Then, whatever the ingenuity of organizations, contracts and policies,*

$$\eta \leq \rho. \qquad (55)$$

Sketch of proof. By A5, conversion passes through the chain in series. Each stage transmits at best what its component lets through: the failure not absorbed financially disappears with its bearer before being sorted; the failure sorted but stigmatized does not circulate; the failure that circulates but is not refinanced generates no new attempt. The product of the passages is bounded by the generalized mean of order $\theta \leq 0$ of the components, hence by ρ. ▫

No management reform, no pedagogy of benevolence, no discourse on the culture of failure carries efficiency above the institutional ceiling. This is the theory's most binding result for policy, because it dictates the order of works: one does not tune the machine before raising the ceiling. The bound plays the role of the speed of light: the quantity that every received theory assumed, without saying so, to equal one. Its stochastic version follows from the measure. Since agents decide on their beliefs,

$$\mathbb{E}[\eta] \leq \int \hat{\rho}\, d\mu - \text{correction de Jensen}, \qquad (56)$$

the effective bound degrades with dispersion: the aggregate flow of attempts is $\int n(\hat{\rho})\, d\mu$, and n is concave in the upper region of the sigmoid, where thawing economies operate. At equal average belief, doubt destroys attempts: each agent tipped below the threshold costs more than his counterpart tipped above brings in. This is the exact formalization of the *freeze by doubt*: a society can be right on average and freeze all the same, because it is not right *together*. The ceiling depends not only on what the law permits, but on what the population believes with one voice.

9.3. The equivalence principle and the field equation

At the instant of decision, the agent does not distinguish the actual regime from the believed regime. A high legal ρ that nobody believes in produces exactly the same attempts, the same refusals and the same freezes as a collapsed legal ρ, since the variable that enters threshold (10) is $\hat{\rho}$, never ρ. This is the *institutional equivalence principle*: locally, the believed law and the real law are indistinguishable; only long trajectories

separate them, at the slow pace of λ^{+}. This principle constrains the fundamental variable to be a *field*: the distribution μ_t, coupled to the stocks. Any policy that reforms the real without touching the believed discovers the equivalence at its own expense.

The stocks obey the master system M1–M7: production $Y = AK^{\alpha}(hL)^{\beta}R^{\gamma}$; attempts $n = n(\hat{\rho})$; split $\dot{R} = \rho\Lambda\varepsilon - \mu_R R$; knowledge $\dot{A} = \delta\rho_c\, n(\hat{\rho})A^{\varphi}$ — whence the convexity, the multiple equilibria and the cusp as generic behavior in the non-convex region; capital $\dot{K} = sY - \mu_K K - \Phi$, dissipation coming as a direct deduction from accumulation, where growth accounting imputes it to the residual; institutions $\dot{\rho} = \iota - \upsilon\rho$, investment against wear — courts that clog, registers that age, clemencies that are forgotten. The field, for its part, obeys a Fokker–Planck–McKean–Vlasov equation with jumps:

$$\frac{\partial \mu}{\partial t} = -\frac{\partial}{\partial \hat{\rho}}\left[v(\hat{\rho}, \mu)\,\mu\right] + \frac{\sigma^2}{2}\frac{\partial^2 \mu}{\partial \hat{\rho}^2} + J[\mu], \qquad (57)$$

where v is the continuous Bayesian drift of Section 5, σ the volatility of beliefs, and J the jump kernel governed by the filter: clemency events carry mass upward, sanction events precipitate it downward, at rates that depend on the intensity of observation and on the gap between perceived and actual regime. The McKean–Vlasov character — the dependence of v and J on μ itself — states the essential point: beliefs do not each adjust to an external signal; they adjust to one another, each agent reading the climate in everyone's falls and rebounds. The life of the field has three tempos: the thaw by slow drift; the freeze by jump, a sanction event splitting the distribution in an instant; and memory — the fraction of the population that remains convinced of the worst long survives the event, a scar inscribed not in the stocks but in the measure.

9.4. The mean-field game: the trap microfounded

Each agent in state x chooses his experimentation intensity ε. His value solves the Hamilton–Jacobi–Bellman equation

$$r\,u(x) = \max_{\varepsilon}\left\{\varepsilon\left[p\,G + (1-p)\left(\partial u_{\exp} - \kappa(1-\hat{\rho})\right)\right] - c(\varepsilon) + \mathcal{L}[u](x)\right\}, \qquad (58)$$

where $\hat{\rho}$ is given to the agent not by an authority, but by the others: each infers the climate from the falls observed, whose flow depends on the distribution m_t of states and of chosen intensities. The loop closes: the distribution generates the belief, the belief commands experimentation, experimentation shapes the distribution. This is a mean-field game in the sense of Lasry and Lions (2007): the backward HJB coupled with the forward Kolmogorov equation, $\partial_t m = -\mathrm{div}(b[\varepsilon^*]m) + \sigma^2/2\,\Delta m$, the equilibrium being a fixed point of the pair (u, m) — existence by Schauder's theorem on a compact convex

set of measure flows. Uniqueness *fails exactly where the theory expects it to*: the Lasry–Lions monotonicity condition is violated by stigma, because the experimentation of others makes mine more attractive, not less — their rebounds warm my $\hat{\rho}$. The induced belief map $\Psi(\hat{\rho})$ cuts the diagonal three times: a prudent equilibrium, where each abstains because all abstain; a bold equilibrium, where visible rebounds sustain the belief that permits them; an unstable threshold, where history decides.

The conformity trap of Section 4 thus receives its complete microfoundations: no longer a postulated aggregate loop, but a demonstrated coordination failure, with selection by history. The causal externality is identified: every fall, every rebound, every silence is a signal paid into the common pot of beliefs, which no agent prices. This is also the general-equilibrium form of the under-supply theorem: markets contingent on errors are structurally incomplete — A3 makes failure information non-rival, stigma makes every fall an externality on the beliefs of third parties — so the competitive equilibrium is not optimal, and equilibrium reversibility is strictly below the optimum. Institutional clemency is a public good in the full sense: non-excludable, non-rival, under-produced, a proper object of taxation.

9.5. Proper time: the relativity of economic clocks

All the conversion laws of the master system advance at the rate of attempts, not of calendars. Knowledge grows when one tries; experience accumulates when one falls and recycles; nothing happens so long as one abstains. Define the *proper time* of an economy by its internal clock,

$$d\tau = \rho_c \, n(\hat{\rho}) \, dt, \qquad (59)$$

and rewrite the law of knowledge in it:

$$\frac{dA}{d\tau} = \delta \, A^{\varphi}. \qquad (60)$$

The equation is universal: stripped of every reference to institutions, the same for every economy in the world. **Proper-time theorem.** *Any two economies traverse the same knowledge trajectory in their own proper time. They differ only by the exchange rate* $d\tau/dt = \rho_c \, n(\hat{\rho})$ *between their clock and the calendar.* A calendar year in a frozen economy contains a few weeks of proper time; the same year in a clement economy contains twelve full months. Underdevelopment thus receives its relativistic definition: *not a lag on another path, but a dilation of time on the same path*. This is why copying an institution or a technology does not copy the learning time that made it effective. The associated prediction is a collapse of the data onto a single curve: plotted in calendar

time, the convergence trajectories of nations diverge in a fan; plotted in estimated proper time, they must superpose onto a single master curve, up to residuals. Any systematic departure refutes the law of knowledge. No growth theory predicts this, because all share Newton's absolute time — the statistical quarter, the same for Seoul as for Bangui.

9.6. Social temperature, escape time and the fluctuation identity

Temperature. Over wide regimes, the evolution of m is a gradient flow in Wasserstein space (Jordan, Kinderlehrer and Otto 1998): a steepest descent of the free energy

$$F[m] = \int U\, dm + \frac{1}{2}\iint W\, dm\, dm + \rho \int m \ln m, \qquad (61)$$

where U is the landscape of individual positions, W the conformity interaction that draws agents toward the positions of others, and where the coefficient of the entropic term — the one that pushes toward exploring, dispersing, trying — is none other than ρ.
Reversibility is the social temperature. At high ρ, entropy dominates: the population explores the landscape, crosses the passes, finds the deep basins. At low ρ, energy dominates: the flow freezes in the first local minimum that comes along, and society vitrifies in the precise sense that physics gives the word — a frozen disorder, each agent immobilized not by the depth of his basin, but by the height of the smallest pass. Underdevelopment is not a lack of possibilities; it is a deficiency of temperature. The clean jump then reappears under its physical name, *annealing*: heating abruptly to unstick the system from its local minimum, then letting it settle in a better basin. Gradualism is slow cooling in the wrong basin.

Escape. The large-deviations theory of Freidlin–Wentzell (1984) generalizes the Kramers time of Section 7.2. For the small-noise diffusion $dX = b(X)\, dt + \sqrt{2\rho\nu}\; dW$ — the amplitude of useful noise, the noise of attempts, being proportional to ρ — the mean exit time from the basin of a trap obeys

$$\mathbb{E}[T_{\text{exit}}] \asymp \exp\left(\frac{V_q}{\rho\, \nu}\right), \qquad (62)$$

where V_q is the quasi-potential: the effective height of the pass along the path of least action. This is the theory's second dilation of time, and the most brutal. Equation (59) dilated growth time linearly; (62) dilates escape time *exponentially*. Each point of ρ lost multiplies the duration of the trap — whence the longevity of traps with crushed ρ, beyond anything the fundamentals justify — and each point gained divides the escape time by an exponential factor — whence the extraordinary return to reversibility reforms. The finest prediction attaches to this: the effective path out of a trap is the least-action

path of the quasi-potential. It is testable on historical exit trajectories — Korea, Ireland, the Baltic states — whose reform sequences should align with the computed paths rather than with the paths of least political resistance.

The fluctuation identity. Stochastic thermodynamics (Jarzynski 1997; Crooks 1999; Seifert 2012) establishes that the ratio of the probabilities of a trajectory and of its reversal measures the entropy produced along the path. Let us apply it to belief trajectories: γ, a freeze over a repressive episode; $\bar{\gamma}$, the symmetric thaw. The construction of the filter gives

$$\omega \;=\; \frac{\mathbb{P}[\gamma]}{\mathbb{P}[\bar{\gamma}]} \;=\; \exp(\Delta S_i): \qquad (63)$$

the distrust coefficient is the exponential of the institutional entropy produced by the episode. Detailed balance, $\omega = 1$, characterizes the only societies whose institutions of memory make freeze and thaw equally probable — reversible in the sense that physics has given the word for a century and a half. Every $\omega > 1$ measures, in logarithm, the quantity of social order irreversibly destroyed per episode. The loop of the construction closes: the quantity that Section 5 posited as a phenomenologist, and that Section 6 measures as a statistician, receives its identity papers from thermodynamics. The word *reversibility*, chosen as an image, turns out to have been a technical term used exactly from the start.

9.7. The curved geometry of reform

Consider the space of regimes $(\rho_f, \rho_j, \rho_s, \rho_c, \rho_p)$ as a five-dimensional Riemannian manifold, M, endowed with a metric $g_{ij}(\rho)$ that encodes complementarities and substitution costs. The cost of an infinitesimal reform displacement is $ds^2 = g_{ij}\, d\rho^i d\rho^j$, with g_{ij} decreasing in ρ_s: crossing the same gap in ρ_j costs little when the bankrupt has a safety net, and dearly when every liquidation is a battle for survival. Geodesic distance on M is the minimal institutional cost of joining two regimes, and the optimal path solves

$$\ddot{\rho}^k + \Gamma^k_{ij}\, \dot{\rho}^i \dot{\rho}^j = 0, \qquad (64)$$

with the Christoffel symbols derived from the metric. Where the metric is uniform, the optimal path is a straight line traversed at constant speed. Where it varies, the least-cost path *curves*: raise ρ_s first, in order to make the later raising of ρ_j cheap — as a ray of light curves in a medium of variable index. The sequencing of reforms is not an execution detail; it is the solution of a second-order differential equation. Two sequences joining the same regimes can differ by a factor of three or four in total cost: in the two-

dimensional sections computed in the treatise, the reverse sequence — bankruptcy law before the safety net — costs nearly four times the geodesic. The metric has a source: in the conformal form $g_{ij} = e^{2\varphi_d}\delta_{ij}$, where $\varphi_d(\rho)$ is the stationary dissipation potential of the regime, dissipative regions are dilated — every displacement there costs more, as mass dilates lengths in gravitation — and the curvature, computed from the second derivatives of φ_d, changes sign exactly at the folds of the cusp: critical transitions appear as the points where the geodesic becomes unstable. Reform twins that diverge under the same written plan — Poland and Ukraine in the nineties — cease to be a puzzle: they measure a curvature.

As a complement to the scalar warning indicators of Section 4.3, a *topological seismograph* reads the global shape of the data: reconstruct the attractor by delay embedding of macroeconomic series, then apply persistent homology to it. As a transition approaches, excursions widen and slow down, persistence bars lengthen: the deformation of the attractor is detected before any mean has moved. The signal is more robust to noise than variance and autocorrelation, and, to our knowledge, without precedent in this application.

9.8. The principle of least stochastic dissipation

As mechanics derives from least action, the general theory derives from a single principle. The planner chooses the trajectory of institutional investment ι_t — courts, safety nets, registers, communication of clemency — so as to minimize discounted dissipation, augmented by the installation cost:

$$\min_{\iota(\cdot)} \mathbb{E} \int_0^\infty e^{-rt} \left[\Phi(\Xi_t) + c(\iota_t)\right] dt, \qquad (65)$$

subject to the master system, the field equation (57) and the constraint that average belief remain above the take-off threshold. The difficulty that makes the problem truthful is *partial observation*: the true ρ is observed neither by the planner nor by the agents — only noisy signals are: falls, rebounds, case law. The problem is therefore one of partially observed stochastic control. Its solution is characterized by an HJB equation posed on the measure, coupled with a filtering equation (Zakai or Kushner–Stratonovich) that updates μ_t along the observations. *The reversibility planner does not steer an economy; he steers a belief about an economy.* The clean-jump theorem emerges from it as a special case. The general formulation adds two tools: partial jumps when uncertainty about the regime is high — one does not spend all one's political capital on a doubtful diagnosis — and *active learning*: deliberately provoking clemency events — the trial of an honest bankrupt concluded in public rehabilitation, a targeted and conspicuously publicized

amnesty — each being at once an impulse on beliefs and an experiment that reveals the regime.

The optimal planner experiments with his own clemency: he applies A1 to himself. The control calculation finally delivers a counter-intuitive result for the budget: when the cost of a clemency event is low — and it is: communication and symbol — this lever *dominates costly structural reforms in the initial phase of the thaw*. Beliefs jump on facts and climb back slowly with durations; at the beginning of a thaw, it is the frozen mass of μ that blocks everything, not the level of ρ. The complete sequence writes itself: jump cleanly on ρ; multiply the events that make it believed; then maintain.

9.9. The correspondence principle

Theorem (correspondence). *Let $T(\rho)$ be any quantity of the general theory — multiplier, contract slope, sovereign spread, investment threshold, aversion coefficient. Its expansion in the neighborhood of the temperate world is written*

$$T(\rho) = T(1) - (1-\rho)\,T'(1) + O((1-\rho)^2), \qquad (66)$$

where $T(1)$ is exactly the canonical value of the received theory, and where the first-order term is exactly the amendment of Section 8. Verification proceeds by inspection: the option premium (43), the aversion surcharge (46), the sovereign premium (49), the entry ticket $W^{\dagger}$, the trade surcharge (35) are all of first order in $(1-\rho)$, as relativistic corrections are of first order in v^2/c^2. Received economic science is therefore not false. It is the zeroth-order term of an expansion whose parameter it did not know: exact where $(1-\rho)$ is negligible — in the temperate economies where it was written — and increasingly in error as one descends toward the frozen economies where it is most applied.

Each of the nine amended theories is obtained from the general system by projection and first-order truncation: trade on differences in ρ, the cycle on memory, finance on Φ, the firm on the split, taxation on both signs, demand on the belief loop, preferences on ω, the sovereign on ρ_p, the contract on A2. The general theory does not add a chapter to the received theories; it identifies their common ancestor and assigns to each its domain of validity.

Two general theorems complete the edifice. *The dissipative bound on growth*: the long-run growth rate satisfies $g \le \hat{g}(\rho)$, an increasing function composed of the channel bound (6) and the law of knowledge. Development is not a speed race between accumulations; it is an efficiency race between conversion systems, and the system with the low ceiling loses even while accumulating more. *Amended welfare*: welfare depends

on the capacity to find a path again after a shock, not on instantaneous allocation alone. The concentration of the right to err produces a cumulative inefficiency that is also an injustice: the equity–efficiency frontier is displaced by a factor that serves both at once, because well-designed clemency is a technology for conserving capabilities. Protecting the person preserves human capital; making assets resalable preserves physical capital; publishing errors preserves cognitive capital; securing alternation in power preserves political capital.

10. What the theory prohibits

A theory is worth what its prohibitions are worth. This one pronounces six, dated and quantifiable. It prohibits: (i) that a country whose Reversibility Index collapses should experience a durable acceleration of its total factor productivity, beyond the reprieve afforded by a rent; (ii) that recoveries should be symmetric to recessions in economies with high ω; (iii) that firm leverage should be independent of ρ_j, at equal taxation; (iv) that a widening of the tax offset of losses should leave unchanged the variance of the projects undertaken; (v) that an estimated significantly positive θ should survive the axiomatics of Section 6 — the arithmetic index must be rejected by the data; (vi) that convergence trajectories, plotted in estimated proper time, should refuse to collapse onto the master curve — the prohibition of the proper-time theorem, and the most demanding test of the theory.

Ten signed predictions organize the empirical program, each testable with available data. (1) The higher the total cost of error, the further innovative entrepreneurship retreats. (2) The stronger the stigma of bankruptcy, the more talent orients itself toward protected careers. (3) The slower liquidation procedures are, the longer capital remains locked in unproductive uses. (4) The more accessible second chances are, the more useful experience serial entrepreneurs produce — founders who have experienced a failure outperform novices wherever a new attempt is permitted. (5) The earlier school punishes error, the more prudent later professional trajectories become. (6) The further a diaspora moves from the social control of its origin, the higher its experimentation rate rises — and the measured loss aversion of migrants converges toward host-country values at the speed λ^{+}. (7) The more finely justice distinguishes accident from fraud, the more clemency society can offer without abuse. (8) The more irreversible the loss of political power, the more tightly leaders cling to it — and the political component of sovereign spreads reopens with every persecution of a former leader. (9) The more frequent crises are, the higher the economic value of reversibility rises — the option logic of 3.4. (10) The more that imported capital arrives in an environment poor in reversibility, the further its effective return falls below its theoretical return. To these are added the structural

signatures already stated: the estimated θ negative; the asymmetric fingerprint of freeze and thaw on cohorts; the bell-shaped multiplier gap, peaking in the middle of the sigmoid; the critical-slowing-down signals preceding documented take-offs and collapses; and the frequency of social tremors falling as their magnitude rises when ρ_p is crushed, according to the conservation identity (34).

The avowed limits define the work ahead. The microfoundations of λ^+ and λ^- remain partly phenomenological: the filter gives their form, the fluctuation relation their thermodynamic identity, not the complete cognitive mechanism. The existence of general equilibrium under the non-convexity of the law of knowledge requires treatment beyond standard fixed-point theorems in the region of the cusp; uniqueness is lost by construction — a feature of the world more than a defect of the model. Measurement is young: indicators of μ_t — constructible from textual data, analyst reports, case law and the press, the distribution of beliefs being readable in the distribution of narratives — and the proper clock remain to be built. The theory will live or die by the panel.

11. Conclusion

This article has argued that a single institutional quantity — the efficiency with which a society converts its failures into reusable capacity — belongs in the production function, and that taking it seriously reorganizes growth theory, the microeconomics of risk, the doctrine of reform and the interpretation of the established corpus. The construction runs from an accounting amendment — a third stock, proportional in the long run to ρ — to microfoundations — a threshold that rationalizes the prudence of the poor without invoking their psychology; to aggregate dynamics — a cusp trap, with measurable early warnings; to belief dynamics — an asymmetric law derived from exact filtering; to measurement — an index whose aggregation structure is itself falsifiable; to optimal policy — an all-or-nothing theorem with a computable trigger; and on to a general theory endowed with an invariant, a field equation, a proper time, a geometry, a variational principle and a correspondence theorem under which received economics is the special case $\rho = 1$.

Three shifts summarize the contribution. *Diagnostic*: the immobility of poor economies ceases to testify to a lack of talent or a preference for rents; it reveals a system in which the consequences of a bad decision spill far beyond the project — an equilibrium produced by institutions and by the beliefs they have deposited. *Normative*: development policy acquires a precise object — reduce the total cost of error; strengthen the weakest link until returns are equalized; protect exploration while sanctioning fraud; jump cleanly rather than crawl; produce the clemency events that make reform credible; read the

warning signals before the crisis. Every prescription follows from an equation; none requires prior wealth; all produce it. *Epistemic*: the established theories are found to have been written under a silent assumption — error can be repaired — true where they were born, false where they are most exported. What has been written here is therefore not an economics of underdevelopment, but a general economics of which the rich economies are the favorable special case: the one where social temperature is high enough to be forgotten in the calculations.

Nations have long measured themselves by their stocks of capital and their headcounts of workers. The theory developed here suggests a third register: the elasticity of their institutions — their aptitude for turning the fall into a rebound, the loss into a lesson, the bankrupt into a candidate for a new attempt. Capital says what nations possess; labor says what they do; reversibility says what they forgive. And forgiveness, put into equations, turns out to be the most productive of the three.

References

Acemoglu, D., S. Johnson and J. A. Robinson (2001). "The Colonial Origins of Comparative Development: An Empirical Investigation." *American Economic Review* 91(5), 1369–1401.

Acemoglu, D., and J. A. Robinson (2012). *Why Nations Fail: The Origins of Power, Prosperity, and Poverty.* Crown.

Achdou, Y., et al. (2022). "Income and Wealth Distribution in Macroeconomics: A Continuous-Time Approach." *Review of Economic Studies* 89(1), 45–86.

Aczél, J. (1966). *Lectures on Functional Equations and Their Applications.* Academic Press.

Aghion, P., and P. Howitt (1992). "A Model of Growth through Creative Destruction." *Econometrica* 60(2), 323–351.

Ambrosio, L., N. Gigli and G. Savaré (2008). *Gradient Flows in Metric Spaces and in the Space of Probability Measures.* Birkhäuser.

Arrow, K. J. (1962). "The Economic Implications of Learning by Doing." *Review of Economic Studies* 29(3), 155–173.

Arthur, W. B. (1989). "Competing Technologies, Increasing Returns, and Lock-In by Historical Events." *Economic Journal* 99(394), 116–131.

Azariadis, C., and A. Drazen (1990). "Threshold Externalities in Economic Development." *Quarterly Journal of Economics* 105(2), 501–526.

Bak, P., C. Tang and K. Wiesenfeld (1987). "Self-Organized Criticality: An Explanation of 1/f Noise." *Physical Review Letters* 59(4), 381–384.

Banerjee, A. V., and E. Duflo (2011). *Poor Economics.* PublicAffairs.

Becker, G. S. (1964). *Human Capital.* Columbia University Press.

Bernanke, B., and M. Gertler (1989). "Agency Costs, Net Worth, and Business Fluctuations." *American Economic Review* 79(1), 14–31.

Blanchard, O. J., and L. H. Summers (1986). "Hysteresis and the European Unemployment Problem." *NBER Macroeconomics Annual* 1, 15–78.

Coase, R. H. (1937). "The Nature of the Firm." *Economica* 4(16), 386–405.

Cover, T. M., and J. A. Thomas (2006). *Elements of Information Theory.* Wiley.

Crooks, G. E. (1999). "Entropy Production Fluctuation Theorem and the Nonequilibrium Work Relation for Free Energy Differences." *Physical Review E* 60(3), 2721–2726.

Cross, R. (1993). "On the Foundations of Hysteresis in Economic Systems." *Economics and Philosophy* 9(1), 53–74.

Dasgupta, P., and D. Ray (1986). "Inequality as a Determinant of Malnutrition and Unemployment: Theory." *Economic Journal* 96(384), 1011–1034.

David, P. A. (1985). "Clio and the Economics of QWERTY." *American Economic Review* 75(2), 332–337.

Dixit, A. K., and R. S. Pindyck (1994). *Investment under Uncertainty.* Princeton University Press.

Domar, E. D., and R. A. Musgrave (1944). "Proportional Income Taxation and Risk-Taking." *Quarterly Journal of Economics* 58(3), 388–422.

Dornbusch, R., S. Fischer and P. A. Samuelson (1977). "Comparative Advantage, Trade, and Payments in a Ricardian Model with a Continuum of Goods." *American Economic Review* 67(5), 823–839.

Eaton, J., and M. Gersovitz (1981). "Debt with Potential Repudiation: Theoretical and Empirical Analysis." *Review of Economic Studies* 48(2), 289–309.

Eichengreen, B., R. Hausmann and U. Panizza (2005). "The Pain of Original Sin." In *Other People's Money*, University of Chicago Press.

Freidlin, M. I., and A. D. Wentzell (1984). *Random Perturbations of Dynamical Systems.* Springer.

Georgescu-Roegen, N. (1971). *The Entropy Law and the Economic Process.* Harvard University Press.

Gittins, J. C. (1979). "Bandit Processes and Dynamic Allocation Indices." *Journal of the Royal Statistical Society B* 41(2), 148–177.

Grossman, S. J., and O. D. Hart (1986). "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration." *Journal of Political Economy* 94(4), 691–719.

Hardy, G. H., J. E. Littlewood and G. Pólya (1934). *Inequalities.* Cambridge University Press.

Hidalgo, C. A., and R. Hausmann (2009). "The Building Blocks of Economic Complexity." *Proceedings of the National Academy of Sciences* 106(26), 10570–10575.

Holling, C. S. (1973). "Resilience and Stability of Ecological Systems." *Annual Review of Ecology and Systematics* 4, 1–23.

Holmström, B., and P. Milgrom (1987). "Aggregation and Linearity in the Provision of Intertemporal Incentives." *Econometrica* 55(2), 303–328.

Jarzynski, C. (1997). "Nonequilibrium Equality for Free Energy Differences." *Physical Review Letters* 78(14), 2690–2693.

Jordan, R., D. Kinderlehrer and F. Otto (1998). "The Variational Formulation of the Fokker–Planck Equation." *SIAM Journal on Mathematical Analysis* 29(1), 1–17.

Kahneman, D., and A. Tversky (1979). "Prospect Theory: An Analysis of Decision under Risk." *Econometrica* 47(2), 263–291.

Khanna, T., and K. Palepu (2000). "Is Group Affiliation Profitable in Emerging Markets? An Analysis of Diversified Indian Business Groups." *Journal of Finance* 55(2), 867–891.

Kiyotaki, N., and J. Moore (1997). "Credit Cycles." *Journal of Political Economy* 105(2), 211–248.

Kramers, H. A. (1940). "Brownian Motion in a Field of Force and the Diffusion Model of Chemical Reactions." *Physica* 7(4), 284–304.

Lasry, J.-M., and P.-L. Lions (2007). "Mean Field Games." *Japanese Journal of Mathematics* 2(1), 229–260.

Lucas, R. E. (1990). "Why Doesn't Capital Flow from Rich to Poor Countries?" *American Economic Review* 80(2), 92–96.

Manso, G. (2011). "Motivating Innovation." *Journal of Finance* 66(5), 1823–1860.

Mayergoyz, I. D. (1986). "Mathematical Models of Hysteresis." *Physical Review Letters* 56(15), 1518–1521.

Melitz, M. J. (2003). "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica* 71(6), 1695–1725.

Merton, R. C. (1974). “On the Pricing of Corporate Debt: The Risk Structure of Interest Rates.” *Journal of Finance* 29(2), 449–470.

Mézard, M., G. Parisi and M. A. Virasoro (1987). *Spin Glass Theory and Beyond.* World Scientific.

Modigliani, F., and M. H. Miller (1958). “The Cost of Capital, Corporation Finance and the Theory of Investment.” *American Economic Review* 48(3), 261–297.

Murphy, K. M., A. Shleifer and R. W. Vishny (1989). “Industrialization and the Big Push.” *Journal of Political Economy* 97(5), 1003–1026.

Nelson, R. R. (1956). “A Theory of the Low-Level Equilibrium Trap in Underdeveloped Economies.” *American Economic Review* 46(5), 894–908.

North, D. C. (1990). *Institutions, Institutional Change and Economic Performance.* Cambridge University Press.

Nurkse, R. (1953). *Problems of Capital Formation in Underdeveloped Countries.* Oxford University Press.

Pontryagin, L. S., et al. (1962). *The Mathematical Theory of Optimal Processes.* Interscience.

Prebisch, R. (1950). *The Economic Development of Latin America and Its Principal Problems.* United Nations.

Preisach, F. (1935). “Über die magnetische Nachwirkung.” *Zeitschrift für Physik* 94, 277–302.

Prigogine, I., and I. Stengers (1979). *La Nouvelle Alliance.* Gallimard.

Ricardo, D. (1817). *On the Principles of Political Economy and Taxation.* John Murray.

Romer, P. M. (1986). “Increasing Returns and Long-Run Growth.” *Journal of Political Economy* 94(5), 1002–1037.

Romer, P. M. (1990). “Endogenous Technological Change.” *Journal of Political Economy* 98(5), S71–S102.

Rosenstein-Rodan, P. N. (1943). “Problems of Industrialisation of Eastern and South-Eastern Europe.” *Economic Journal* 53(210/211), 202–211.

Sachs, J. D. (2001). “Tropical Underdevelopment.” NBER Working Paper 8119.

Scheffer, M., et al. (2009). “Early-Warning Signals for Critical Transitions.” *Nature* 461, 53–59.

Schumpeter, J. A. (1942). *Capitalism, Socialism and Democracy.* Harper.

Seifert, U. (2012). “Stochastic Thermodynamics, Fluctuation Theorems and Molecular Machines.” *Reports on Progress in Physics* 75(12), 126001.

Sen, A. (1981). *Poverty and Famines: An Essay on Entitlement and Deprivation.* Oxford University Press.

Shannon, C. E. (1948). “A Mathematical Theory of Communication.” *Bell System Technical Journal* 27, 379–423, 623–656.

Solow, R. M. (1956). “A Contribution to the Theory of Economic Growth.” *Quarterly Journal of Economics* 70(1), 65–94.

Solow, R. M. (1957). “Technical Change and the Aggregate Production Function.” *Review of Economics and Statistics* 39(3), 312–320.

Thom, R. (1972). *Stabilité structurelle et morphogenèse.* Benjamin.

Williamson, O. E. (1985). *The Economic Institutions of Capitalism.* Free Press.

Wonham, W. M. (1964). “Some Applications of Stochastic Differential Equations to Optimal Nonlinear Filtering.” *SIAM Journal on Control* 2(3), 347–369.

Zeeman, E. C. (1977). *Catastrophe Theory: Selected Papers.* Addison-Wesley.