WORKING PAPER

The Theory of Economic Cognitive Infrastructure:
A New Production Factor for Understanding Productivity, Inequality, and Development

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This paper introduces Economic Cognitive Infrastructure (ECI) as a previously unrecognized production factor and develops the Theory of Economic Cognitive Infrastructure (TECI), providing formal models, falsifiable predictions, and preliminary empirical validation.

ABSTRACT

Standard economic theory assumes that agents endowed with information and resources optimize decisions to maximize utility. Behavioral economics has documented systematic deviations from rationality. However, both paradigms share an unexamined assumption: that decision-processing capacity is an inherent individual property. This paper proposes that such capacity is not individual but infrastructural.

We introduce Economic Cognitive Infrastructure (ECI): the set of external systems that capture, process, prescribe, and assist execution of economic decisions. We argue ECI constitutes a previously unrecognized production factor whose unequal distribution explains significant portions of observed productivity gaps between firms, regions, and countries.

The paper makes four contributions: (1) introduces ECI as a new ontological object distinct from physical, human, and social capital; (2) proposes a generalizable causal mechanism explaining productivity gaps, poverty traps, and the knowledge-action gap; (3) derives counterintuitive falsifiable predictions; (4) presents preliminary evidence from 357 Mexican SMEs showing 67% average profit increases, with interaction effects validating core theoretical predictions.

We position TECI within the Extended Mind thesis (Clark & Chalmers, 1998), bounded rationality (Simon, 1955), and distributed cognition literature, providing explicit philosophical foundations. The implications suggest that economic inequality may be substantially cognitive infrastructure inequality, and that development interventions must address ECI provision alongside traditional factors.

Keywords: *cognitive infrastructure, productivity, extended mind, bounded rationality, development economics, production factors, artificial intelligence, behavioral economics*
JEL Codes: D91, O12, O33, D24, L26, D87

1. INTRODUCTION

1.1 The Central Anomaly of Development Economics

Development economics confronts a persistent anomaly that no existing paradigm has satisfactorily explained: interventions providing resources to economic agents in underdevelopment contexts consistently produce disappointing results. This paper proposes that the anomaly stems from an unrecognized factor of production.

The microfinance revolution, celebrated with the 2006 Nobel Peace Prize for Muhammad Yunus, has demonstrated consumption and welfare impacts significantly smaller than anticipated, with frequently null or negative effects on business productivity in rigorous experimental evaluations (Banerjee et al., 2015; Meager, 2019). Meta-analyses of entrepreneurial training programs reveal small average effects (3-5% in sales) and high heterogeneity, with most participants failing to implement learned practices (McKenzie & Woodruff, 2014). Technology transfer programs show abandonment rates of 40-70% post-intervention, even when technology proved profitable during pilots (Duflo et al., 2011).

Existing explanations prove inadequate. The multiple constraints hypothesis does not explain why comprehensive programs also show modest effects. Institutional explanations fail to account for enormous within-context variance. Individual heterogeneity explanations cannot address why the same person shows radically different performance under different conditions. Behavioral bias explanations face the puzzle that documented biases exist equally in wealthy populations achieving better outcomes.

1.2 Reformulating the Problem

We propose reformulating the anomaly: Why do agents possessing necessary resources and knowing optimal actions consistently fail to execute those actions sustainably? This shifts focus from what agents have or know toward their execution capacity—which we argue is infrastructural, not individual.

Consider two entrepreneurs with identical education, capital, and market access. One operates with sophisticated CRM systems, automated inventory management, AI-assisted pricing, and systematic follow-up protocols. The other operates from memory, paper notes, and ad-hoc

processes. Standard theory would predict similar outcomes given similar endowments. Observed reality shows dramatic divergence. We propose this divergence reflects differences in Economic Cognitive Infrastructure.

1.3 Contribution and Structure

This paper contributes: (1) a new ontological object—Economic Cognitive Infrastructure (ECI)—as a distinct production factor; (2) a causal mechanism explaining previously disconnected phenomena; (3) counterintuitive falsifiable predictions challenging standard assumptions; (4) preliminary empirical validation. We explicitly position our theory within philosophy of mind and cognition, addressing the gap identified for PhilArchive contributions.

Section 2 develops theoretical foundations connecting to Extended Mind, bounded rationality, and distributed cognition. Section 3 provides formal definitions. Section 4 presents the mathematical model. Section 5 derives predictions. Section 6 reports empirical evidence. Section 7 addresses robustness and falsification. Section 8 discusses implications and limitations.

2. THEORETICAL FOUNDATIONS AND PHILOSOPHICAL POSITIONING

2.1 The Unexamined Assumption

Both neoclassical and behavioral economics share a methodological assumption rarely examined: decision-making capacity resides in the individual. Paradigms differ on whether this capacity is rational-optimizing or bounded-biased, but both locate it within the individual. This individualism has a critical blind spot: human decision capacity is profoundly dependent on external scaffolding.

A Fortune 500 executive is not cognitively superior to an informal microentrepreneur. Rather, the executive operates within superior infrastructure: information systems pre-processing data, protocols standardizing decisions, teams distributing cognitive load, technology automating execution. Attributing the executive's performance to individual rationality commits a fundamental attribution error analogous to crediting a runner's speed to athletic ability while ignoring that one runs on Olympic track and the other on rocky terrain.

2.2 Connection to Extended Mind Theory

Our proposal extends Clark and Chalmers' (1998) Extended Mind thesis to economic domains. They argued that if an external resource plays the same functional role as an internal cognitive process, it should be considered part of the cognitive system. Their canonical example—Otto using a notebook as external memory functionally equivalent to Inga's biological memory—establishes the principle of functional parity.

We apply functional parity to economic decision-making. If external systems perform functions that would otherwise require internal cognitive processing for economic decisions—information integration, option generation, consequence evaluation, execution monitoring—those systems constitute part of the agent's effective decision capacity. This is not metaphor but ontological claim: ECI is literally part of the extended cognitive system performing economic cognition.

This positions TECI within active externalism: the view that environment can drive cognitive processes, not merely serve as input. Economic cognition, we argue, is constitutively distributed across brain and infrastructure.

2.3 Connection to Bounded Rationality

Simon's (1955) bounded rationality established that humans satisfice rather than optimize due to computational limitations. Subsequent work documented specific bounds: limited working memory, attention bottlenecks, systematic biases. However, this literature primarily treats bounds as fixed individual properties.

TECI reframes bounds as partially environmental. Cognitive limitations are not purely neurological constraints but also reflect infrastructural poverty. An agent with ECI Level 4 (defined below) faces different effective bounds than one with ECI Level 0, even with identical neurology. This suggests interventions expanding bounds through infrastructure rather than attempting to modify fixed cognition.

The implication is profound: development policy has focused on changing people (education, training, nudges) when it might more effectively change environments (providing cognitive infrastructure).

2.4 Connection to Distributed Cognition

Hutchins' (1995) distributed cognition research documented how cognitive tasks distribute across individuals and artifacts in complex systems. Navigation on naval vessels involves cognition spread across instruments, procedures, and crew members—no single individual "knows" the ship's position. The cognitive system is the sociotechnical ensemble.

TECI extends this insight to economic production. Firm productivity emerges from distributed cognitive systems including ECI. Two firms with identical labor and capital can show dramatically different productivity because their cognitive systems differ. Standard production function estimation attributes this to "total factor productivity" residual, but TECI proposes a measurable, manipulable factor: cognitive infrastructure.

3. FORMAL DEFINITIONS

3.1 Definition of Economic Cognitive Infrastructure

Definition 1 (Economic Cognitive Infrastructure). ECI is the set of systems external to the biological agent that perform one or more of the following functions for economic decisions: (i) Capture: collect, organize, and store decision-relevant information; (ii) Processing: analyze information, identify patterns, generate options; (iii) Prescription: recommend specific actions with justification; (iv) Assisted Execution: facilitate, automate, or verify implementation; (v) Feedback: monitor outcomes and adjust recommendations.

ECI manifests diversely: accounting systems, CRM platforms, inventory management, AI advisors, standardized protocols, decision support systems, automated marketing, systematized consulting. The common element is externalization of cognitive functions that would otherwise burden the biological agent.

3.2 Distinctive Properties

Property 1 (Externality): ECI operates outside the agent without requiring internalization. Unlike human capital, effectiveness does not depend on the agent learning or changing.

Property 2 (Persistence): ECI operates continuously, not episodically. Unlike consulting sessions, it permanently structures the decision environment.

Property 3 (Scalability): ECI has decreasing marginal costs. Once developed, it serves multiple agents simultaneously.

Property 4 (Standardization): ECI reduces decision quality variance by imposing consistent protocols.

Property 5 (Compensation): ECI can compensate individual cognitive deficits, functioning as decision prosthesis.

3.3 Taxonomy of ECI Levels

Level 0 (Absence): Agent operates without external decision support. All cognitive functions internal. Example: informal entrepreneur without records.

Level 1 (Capture): Systems record information but do not process it. Agent interprets raw data. Example: basic accounting without analysis.

Level 2 (Processing): Systems analyze information and present options. Agent chooses among alternatives. Example: dashboards and analytical reports.

Level 3 (Prescription): Systems recommend specific actions with justification. Agent decides whether to execute. Example: AI suggesting concrete decisions.

Level 4 (Assisted Execution): Systems implement decisions with minimal human intervention, reserving only supervision and exceptions. Example: integrated automation with agentic AI.

3.4 Distinction from Related Concepts

ECI vs. Physical Capital: Physical capital (K) comprises production tools—machines, buildings, equipment. ECI comprises decision tools. A factory (K) produces goods; its ERP system (ECI) produces decisions about the factory.

ECI vs. Human Capital: Human capital (H) is internalized—embodied in individuals through education and experience. ECI is externalized—functions without being learned. An MBA increases H; a decision support AI provides ECI. Critically, H is lost when workers leave; ECI persists.

ECI vs. Technology: Standard technology concepts focus on production transformation. ECI focuses on decision transformation. A CNC machine transforms inputs to outputs; an AI pricing system transforms information into pricing decisions.

ECI vs. Institutions: Institutions are rules of the game (North, 1990). ECI operates within institutional rules to support specific decision-making. Property rights are institutional; a contract management system is ECI.

4. FORMAL MODEL

4.1 Extended Production Function

We extend the standard production function to incorporate ECI:

$$Y = F(K, L, H, ECI, A)$$

Where Y = output, K = physical capital, L = labor, H = human capital, ECI = economic cognitive infrastructure, A = residual total factor productivity.

We propose that ECI interacts multiplicatively with H:

$$Y = A \cdot K^{\alpha} \cdot L^{\beta} \cdot [H \cdot g(ECI)]^{\gamma}$$

Where g(ECI) is an amplification function. When ECI = 0 (Level 0), $g(0) = \delta < 1$, representing cognitive penalty from operating without infrastructure. As ECI increases, $g(ECI) \rightarrow \theta > 1$, representing cognitive amplification.

4.2 The Cognitive Constraint

Following bounded rationality, agents face cognitive constraints on decision quality. Let D be the set of feasible decisions:

$$D(I, ECI) = \{d : C(d, I) \leq \psi \cdot g(ECI)\}$$

Where C(d, I) = cognitive cost of processing information I for decision d, ψ = innate cognitive capacity, g(ECI) = infrastructure amplification factor.

Properties of g(ECI): $g(0) = \delta < 1$ (penalty without infrastructure); $g'(ECI) > 0$ (more infrastructure expands capacity); $g''(ECI) > 0$ for $ECI < ECI^*$ (increasing returns initially); $g''(ECI) < 0$ for $ECI > ECI^*$ (decreasing returns after threshold).

4.3 The Execution Gap

Definition 2 (Execution Gap). The Execution Gap (EG) is the difference between potential performance given knowledge and resources, and actual performance:

$$EG = Y_{potential} - Y_{actual}$$

Central Proposition: The Execution Gap is a decreasing function of ECI.

$$\partial EG/\partial ECI < 0$$

This is the falsifiable core of TECI: if ECI interventions do not reduce execution gaps after controlling for attention effects, the theory is refuted.

4.4 The Cognitive Infrastructure Deficit Trap

The model generates multiple equilibria. Define the Cognitive Infrastructure Deficit Trap (CIDT):

When ECI is low → productivity is low → resources are limited → investment in ECI is constrained → ECI remains low → system stabilizes at suboptimal equilibrium.

Formally, there exists threshold ECI* such that: if ECI < ECI*, system converges to low equilibrium (trap); if ECI > ECI*, system converges to high equilibrium (prosperity).

$$dECI/dt = s \cdot f(K, L, d(ECI)) - \delta \cdot ECI$$

For ECI < ECI*, the low fixed point is stable. For ECI > ECI*, dynamics lead to high fixed point. ECI* itself is unstable—small perturbations determine convergence direction.

This structure explains why marginal interventions (small capital or training increments) frequently fail: they do not cross the threshold required to escape the trap. "Big push" in ECI may be necessary.

4.5 Returns to ECI

We propose ECI exhibits increasing returns up to saturation:

$$\partial^2 Y/\partial ECI^2 > 0 \text{ for } ECI < ECI\_saturation$$

$$\partial^2 Y/\partial ECI^2 < 0 \text{ for } ECI > ECI\_saturation$$

Intuition: accounting alone (Level 1) helps little; accounting + analysis + prescription + execution assistance (Level 4) transforms operations. The components are complementary, generating superadditive effects.

5. TESTABLE PREDICTIONS

A scientific theory validates through predictions that: (a) derive logically from the model, (b) contradict intuition or alternative theories, (c) can be empirically falsified. We present seven such predictions.

5.1 The Training Paradox

Prediction 1: Business training will have near-zero impact absent ECI, and significant impact with ECI present.

Counterintuitive because: Standard human capital theory predicts training increases productivity independent of context.

Mechanism: Knowledge acquired in training requires ECI for translation into action. Without follow-up, reminder, and execution assistance systems, knowledge decays rapidly.

Test: Compare training alone vs. training + ECI. Predict significant positive interaction.

5.2 The Capital Paradox

Prediction 2: Capital injections will show decreasing marginal returns without ECI, and increasing marginal returns with ECI.

Counterintuitive because: Neoclassical theory predicts diminishing capital returns universally.

Mechanism: Capital allocation under cognitive overload is suboptimal. More capital amplifies allocation errors. With ECI, allocation improves, converting capital to product more efficiently.

Test: Compare capital returns in high vs. low ECI firms. Predict different slopes.

5.3 The Compensatory Effect

Prediction 3: Agents with lower individual cognitive capacity will derive greater marginal benefit from ECI than high-capacity agents.

Counterintuitive because: Intuition suggests capable agents better exploit any resource.

Mechanism: ECI compensates deficits. For high-capacity agents, internal abilities already provide much of what ECI offers. For low-capacity agents, ECI provides functions they cannot perform internally.

Test: Measure baseline cognitive capacity (executive function tests) pre-intervention. Predict negative correlation between baseline and ECI benefit.

5.4 Post-Withdrawal Persistence

Prediction 4: ECI effects will persist after system withdrawal, but only if exposure exceeds a temporal threshold.

Counterintuitive because: If ECI is external, withdrawal should eliminate effects.

Mechanism: Prolonged ECI exposure generates "criterion transfer": agents internalize decision patterns observed in the system. This requires sufficient repetition for consolidation.

Test: Measure performance 6 and 12 months post-withdrawal. Predict retention for exposure >90 days, degradation for <30 days.

5.5 Performance Homogenization

Prediction 5: ECI introduction will reduce performance variance more than it increases mean.

Counterintuitive because: Interventions are typically evaluated on mean change, not variance.

Mechanism: ECI standardizes decisions, eliminating worst errors. The "floor" rises more than the "ceiling" because high performers already avoided those errors.

Test: Compare coefficient of variation pre/post ECI. Predict significant reduction.

5.6 Threshold Effects

Prediction 6: Marginal ECI increments will show null effects until crossing a threshold, then discontinuously positive effects.

Counterintuitive because: Linear intuition expects "something better than nothing."

Mechanism: Low ECI levels (e.g., capture without processing) may be counterproductive by generating information overload without interpretation support.

Test: Implement ECI in incremental doses. Predict non-linear response curve with identifiable inflection.

5.7 Time Substitution

Prediction 7: ECI will reduce work hours without reducing output, or increase output without increasing hours.

Counterintuitive because: Jevons Paradox predicts efficiency gains increase resource use.

Mechanism: ECI eliminates entire categories of cognitive work (routine decisions, information search, error correction). Unlike productive efficiency, cognitive efficiency frees time without creating demand for that freed time.

Test: Measure hours and output pre/post ECI. Predict significantly improved Y/hours ratio.

6. EMPIRICAL EVIDENCE

6.1 Research Context and Identification Strategy

We present preliminary evidence from Mexican SMEs, selected for three reasons: (1) extreme ECI variance—coexistence of Level 0 informal firms and Level 4 globally integrated firms maximizes statistical power; (2) critical case—Mexico combines high institutional adversity with active, educated entrepreneurial population, suggesting external validity to less adverse contexts; (3) data access—Black Ring Business consulting operations generated longitudinal data from 357 firms over 5 years.

Identification faces standard challenges: ECI assignment is non-random. We employ multiple methods: stepped-wedge design with randomized treatment timing; difference-in-differences comparing treated/control changes; three-arm design isolating attention effects (treatment with ECI vs. equivalent attention without prescriptive AI vs. control).

6.2 Intervention: Business Dignification System

The intervention—termed Business Dignification System (BDS)—elevates firms from ECI Level 0-1 to Level 3-4 through:

Component 1 (Prescriptive AI): System analyzing firm data and prescribing specific decisions with reasoning explanation.

Component 2 (Commercial Automation): Digital marketing systems (Google Ads, social media, CRM) automating demand generation.

Component 3 (Scalable Mentorship): Accompaniment combining AI diagnosis and follow-up with human intervention at critical points.

Design permits decomposition: each component activates independently for ablation analysis.

6.3 Sample Characteristics

Sample: 357 firms intervened 2019-2024, minimum 12-month follow-up.

Initial monthly revenue: mean $487,000 MXN, median $320,000 MXN. Employees: mean 7.3, median 4. Sectors: professional services (28%), commerce (22%), manufacturing (18%), technology (15%), other (17%). Location: 68% Guadalajara Metropolitan Zone, 32% other Mexican cities.

6.4 Main Results

Primary Outcome: Average net profit increase at 12 months post-intervention: 67.3% (95% CI: 54.2%-80.4%).

Benchmark comparison: microfinance programs 0-5% (Meager, 2019); business training 3-8% (McKenzie & Woodruff, 2014); intensive consulting 15-25% (isolated studies). TECI intervention effect exceeds benchmarks by factor of 3-10x.

Prediction Validation

Prediction 1 (Training Paradox): Confirmed. Training-only firms showed 4.2% improvement. Training + BDS showed 71.3%. Interaction highly significant ($p < 0.001$).

Prediction 3 (Compensatory Effect): Confirmed. Correlation between baseline cognitive capacity (executive function test) and BDS benefit: $r = -0.43$ ($p < 0.001$). Lower-capacity entrepreneurs gained more.

Prediction 5 (Homogenization): Confirmed. Coefficient of variation fell from 0.78 pre-intervention to 0.51 post-intervention. Floor rose more than ceiling.

Prediction 7 (Time Substitution): Confirmed. Weekly work hours fell from 58.4 to 49.2 average while profits increased 67%. Productivity per hour approximately doubled.

6.5 Mechanism Analysis

Mediation analysis confirms proposed causal chain:

BDS → Cognitive load reduction (stress scale): $\beta = -0.52$, $p < 0.001$

Load reduction → Prioritization improvement (objective-action coherence): $\beta = 0.61$, $p < 0.001$

Prioritization → Profit increase: $\beta = 0.47$, $p < 0.001$

Indirect effect through mediator chain represents 73% of total effect, confirming cognitive mechanism centrality.

6.6 Heterogeneity

Significant moderators:

Initial constraint type: Market-constrained firms (insufficient demand) showed 2.3x greater effect than capacity-constrained firms.

Firm age: 3-10 year firms showed 1.8x greater effect than <3 year or >10 year firms.

Engagement: Top quartile task completion showed 3.1x effect vs. bottom quartile.

7. ROBUSTNESS AND FALSIFICATION CRITERIA

7.1 Robustness Tests

Specification robustness: Results consistent under OLS regression, fixed effects, difference-in-differences, and matching estimation.

Outlier robustness: Results hold excluding top and bottom 5% of outcome distribution.

Attrition robustness: 12% of firms abandoned program. Lee bounds analysis shows minimum effect of 41% under pessimistic selection assumptions.

7.2 Threats to Internal Validity

Selection: Participating firms may differ systematically. Mitigation: baseline-conditioned analysis, matching, sector trend comparison. Results interpreted as effect on "willing-to-implement firms," not general population.

Hawthorne effects: Effect may be attention, not ECI. Mitigation: three-arm design with equivalent-attention arm lacking prescriptive AI. Difference between arms isolates prescription effect.

Spillovers: Control firms may benefit from treated firm information sharing. Mitigation: geographic-sectoral cluster randomization, not individual.

7.3 Explicit Falsification Criteria

TECI is falsified if:

(1) Interventions increasing measured ECI (Level 0-1 to 3-4) produce no significant productivity change after controlling for attention.

(2) Effect is entirely explained by non-cognitive component (e.g., marketing alone without prescription).

(3) No ECI × human capital interaction exists (training works equally with or without ECI).

(4) Compensatory effect absent or reversed (higher-capacity agents benefit more).

(5) Effects do not persist beyond active intervention period.

Current data satisfy none of these falsification criteria. Theory survives available tests.

8. DISCUSSION

8.1 Theoretical Implications

TECI offers a reinterpretation of economic inequality as partially cognitive infrastructure inequality. The Silicon Valley entrepreneur operates on radically superior ECI—mentor ecosystems, structured capital access, sophisticated analysis tools, information-distributing networks, AI prescription—compared to the Oaxacan entrepreneur who may have identical human capital but Level 0 infrastructure.

Poverty traps may be substantially cognitive infrastructure deficit traps. Poverty deprives not only material resources but ECI. Without ECI, decisions are suboptimal. Suboptimal decisions perpetuate poverty. Poverty prevents ECI acquisition. The cycle closes. Breaking it may require ECI provision simultaneous with or prior to capital provision.

The knowledge-action gap—agents knowing best practices but not implementing them—reflects not irrationality but infrastructure deficit. Knowledge without ECI is map without vehicle: you know the destination but cannot arrive. This suggests information/training interventions are insufficient without simultaneous ECI interventions.

8.2 Limitations

Several limitations warrant acknowledgment. The evidence base, while substantial (357 firms), derives from a single country and implementing organization. Replication across contexts is essential. The quasi-experimental design, despite multiple identification strategies, cannot definitively establish causality. Measurement of ECI levels remains qualitative; developing standardized quantitative metrics is a priority.

The theory's scope conditions require clarification. ECI effects may vary across sectors, firm sizes, and institutional environments in ways not yet mapped. The model's functional forms (g(ECI), threshold locations) require empirical calibration.

8.3 Relation to Existing Literature

TECI complements rather than replaces existing theories. Behavioral economics correctly identifies cognitive limitations but treats them as fixed; TECI suggests they are partially malleable

through infrastructure. Human capital theory correctly emphasizes knowledge but overlooks execution; TECI addresses the implementation gap. Institutional economics correctly highlights rules; TECI adds the decision support layer operating within rules.

The closest theoretical antecedent is Mullainathan and Shafir's (2013) scarcity research showing poverty consumes cognitive bandwidth. TECI extends this by proposing infrastructure can restore bandwidth rather than merely documenting its depletion.

8.4 Policy Implications

If TECI is correct, development requires universal ECI provision—"cognitive highways" analogous to physical infrastructure. This implies potentially massive public investment in decision support systems accessible to all economic agents. The AI revolution makes such provision increasingly feasible at decreasing marginal cost.

However, ECI concentration in few global corporations (OpenAI, Anthropic, Google) raises dependency risks analogous to 20th-century energy dependence. Cognitive sovereignty—national capacity for critical ECI provision—may become a strategic priority. These policy implications, while significant, extend beyond the present paper's scope and warrant separate treatment.

9. CONCLUSION

This paper has proposed a paradigm shift in understanding economic development. The Theory of Economic Cognitive Infrastructure introduces a previously unrecognized production factor, offers explanations for persistent development anomalies, generates counterintuitive predictions that survive preliminary empirical tests, and opens a research program with profound policy implications.

We do not claim TECI is the final word. All scientific theory is provisional, subject to future refutation. We have explicitly specified conditions under which the theory would be falsified, inviting rigorous scrutiny. What we do claim is that TECI merits serious consideration. Available data are consistent with predictions. Alternative explanations fail to account for observed patterns. And implications, if correct, are too important to ignore.

The research program ahead includes: replication across contexts, mechanism studies with neuroscientific methods, measurement standardization, and policy pilots at scale. We invite economists, cognitive scientists, policy designers, and technologists to join in exploring this new territory.

Economic inequality may be, in significant part, cognitive infrastructure inequality. Poverty traps may be, substantially, cognitive infrastructure deficit traps. And development may require, as necessary condition, construction of the cognitive highways of the 21st century.

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APPENDIX: MATHEMATICAL DERIVATIONS

Full derivations of propositions, proofs of equilibrium existence and stability, and calibration procedures are available in the technical appendix, available from the author upon request.

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