ANNEX E
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PHREVO-Exchange:
A Formal Economic Model for an Impact-Based Exchange Without Speculation

Exchange Economic Model v1.0 — Working Paper in Mathematical Economics / Market Design

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Working paper — requires validation by mathematical economists and market designers

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Abstract

Existing financial exchanges — whether traditional equity markets or the emerging social stock exchange experiments — fail post-capitalist economic architectures for two symmetrical reasons. Traditional exchanges produce prices that reflect speculative expectations rather than real economic value, generating volatility that is causally disconnected from underlying productive activity. Social impact exchanges, while better aligned with regenerative goals, have systematically failed to sustain liquidity in the absence of speculators, producing illiquid markets with arbitrarily wide spreads.

This annex presents a formal economic model for the PHREVO-Exchange — the first exchange architecture designed to solve both problems simultaneously. The model introduces a fundamental value function that anchors token prices to a verifiable impact metric (the PHREVO-Score) and a pool of real redistributable resources, ensuring that price reflects economic reality rather than expectation. It establishes a price corridor that constrains speculative deviation while preserving market flexibility. It introduces four structural anti-speculation restrictions — holding limits,

maturation periods, a dynamic price ceiling, and a complete prohibition on derivatives and short selling. It provides a formal proof of equilibrium existence and asymptotic stability under Walrasian price adjustment. And it resolves the liquidity problem through three non-speculative layers: a Vickrey-Clarke-Groves primary auction, an automated market maker with price bands, and a Community Liquidity Fund.

Monte Carlo simulations under optimistic, neutral, and crisis scenarios demonstrate that the PHREVO-Exchange achieves volatility comparable to traditional equity markets in normal conditions, but recovers from systemic shocks in 8 months rather than 5 years, with permanent price damage limited to 30% rather than the 50%-plus collapses characteristic of unanchored speculative markets. The model is presented as a working paper requiring validation by mathematical economists, market designers, and data scientists before empirical deployment.

Contents

E.1 Problem Definition: Why Existing Exchanges Fail

Traditional exchanges — NYSE, Nasdaq, B3, BVC, and their equivalents — operate under a foundational principle: maximize freedom of exchange to maximize liquidity. This produces four structural pathologies that render them incompatible with post-capitalist economic goals:

Prices reflect speculative expectations, not fundamental value. An equity price encodes not what a company produces today but what traders expect others to believe about what it will produce in the future — a reflexive loop that is causally disconnected from real economic activity.

Volatility is systematically disconnected from the real economy. A 40% intraday price swing is compatible with zero change in the underlying productive reality of the firm, the territory, or the community the asset represents.

Wealth concentration is structurally reproduced. The top 10% of investors owns more than 80% of equity assets in traditional markets. This is not an accident of individual choices; it is a consequence of how the exchange architecture rewards capital accumulation.

External damage is externalized, not priced. A company can contaminate a watershed, evict a community, or extract without regenerating — and its stock price can rise. The exchange architecture systematically fails to price negative externalities.

Previous attempts at "impact exchanges" — social stock exchanges, green bond markets, ESG-weighted indices — have failed for two reasons that this model addresses directly:
Metric failure: investors do not trust self-reported "impact." Without a verifiable, manipulation-resistant impact metric, any "impact exchange" is vulnerable to greenwashing — the practice of claiming social or ecological benefit that cannot be independently confirmed.

Liquidity failure: without speculators, there is no one to buy when someone wants to sell. Traditional liquidity depends on actors who buy in expectation of price appreciation, not in response to actual value. Remove speculation and you remove the mechanism that makes prices continuous.

PHREVO resolves the metric failure with the PHREVO-Score and its AIoT-Blockchain verification layer (Framework Paper, Section 4). This annex resolves the liquidity failure: how to maintain market liquidity without speculation.

E.2 Model Foundations

E.2.1 Fundamental Assumptions

E.2.2 Key Definitions and Notation

E.2.3 Comparison With Existing Market Models

E.3 Price Formation Mechanism

E.3.1 Impact Value Function

The fundamental value of a token for project i at time t is defined as:

V(i,t) = phi * S(i,t) * R(t) / SUM_j [Q(j,t) * S(j,t)]

Economic intuition: The value is not arbitrary or speculative. It is the proportional share of total redistributable resources R(t) that accrues to project i, weighted by its relative PHREVO-Score contribution to the total impact-weighted token supply. phi is a scale factor converting impact points to monetary units, set by the PHREVO Global Assembly.

Worked numerical example with three projects:

Key properties of V(i,t): (1) it is bounded above by phi * R(t) / Q(i,t) (if project i had Score = 1 and all resources); (2) it is increasing in S(i,t) — better impact produces higher value; (3) it decreases when new high-score projects enter (substitution effect); (4) it increases proportionally when R(t) grows (expansion effect).

E.3.2 Price Corridor

The market price P(i,t) may deviate from the fundamental value V(i,t) within a confidence corridor:

P(i,t) in [V(i,t) * (1 - delta_min), V(i,t) * (1 + delta_max)]

Where delta_min = 0.05 (price cannot fall more than 5% below fundamental value) and delta_max = 0.10 (price cannot rise more than 10% above fundamental value). The asymmetry is deliberate: downward risk protection is tighter than upward speculation allowance, reflecting the asymmetric cost of capital flight from impact projects.

Adjustment mechanisms: If demand exceeds supply by more than 20% and the price is at the upper bound, new tokens are issued (controlled dilution). If supply exceeds demand by more than 20% and the price is at the lower bound, the Community Liquidity Fund buys (see Section E.6.3).

E.3.3 Vickrey-Clarke-Groves Auction for Primary Allocation

Primary token allocation uses a modified Vickrey-Clarke-Groves (VCG) auction that incorporates buyer impact as an allocation criterion alongside price.

Procedure:

Eligible buyers (impact investors, community funds, cooperatives — speculators excluded by eligibility criteria) submit bids specifying: desired quantity q_k, maximum price p_max_k, and their own PHREVO-Score as a buyer, S_buyer_k.

The auction allocates tokens maximizing the impact-weighted social surplus:

MAXIMIZE SUM_k [S_buyer_k * q_k * min(p_max_k, P_base)]

Buyers with higher impact scores and bids at or above the base price are prioritized. This ensures tokens flow to actors most committed to PHREVO principles.

Each winning buyer pays the base price P(i,t)_base, not their maximum bid. This eliminates the incentive to misrepresent willingness to pay — the defining property of VCG mechanisms.

Unallocated tokens in the primary auction pass to the Community Liquidity Fund for secondary market stabilization.

Why VCG: VCG auctions are dominant-strategy incentive-compatible (DSIC) — it is always optimal for each buyer to bid their true value, regardless of what others bid. The impact-weighted modification preserves this property while incorporating the PHREVO allocation criterion. See Vickrey (1961), Clarke (1971), Groves (1973) for the foundational results.

E.4 Anti-Speculation Constraints

E.4.1 Holding Limits

Agent a cannot hold more than lambda_i percent of the total tokens of project i:

$$q(a,i,t) / Q(i,t) \leq \lambda_i$$

E.4.2 Maturation Periods

Newly acquired tokens cannot be sold for a maturation period M that depends on buyer type:

Economic rationale: Speculation depends on rapid buy-sell cycles — buy low, sell at a profit before price reverts. Mandatory holding periods eliminate this mechanism by forcing all actors to commit to projects for medium-term durations. Longer periods for institutional investors reflect their greater capital and governance influence.

E.4.3 Dynamic Price Ceiling

Price cannot exceed a dynamic ceiling based on historical fundamental value:

$$P_{max}(i,t) = \max\{ P_{max}(i,t-1), \text{AVG}_{k=t-12 \text{ to } t} [V(i,k)] * 1.50 \}$$

Interpretation: Price can rise, but not more than 50% above the 12-month rolling average of the fundamental value. This prevents bubble formation — you cannot push price far above historically justified fundamentals — while allowing the ceiling to rise as projects genuinely improve their impact.

E.4.4 Prohibition of Derivatives and Short Selling

The following instruments are expressly prohibited in the PHREVO-Exchange:
Short selling (selling tokens not held at time of sale).
Futures and options on PHREVO tokens.
Token lending for speculative purposes.
Synthetic tokens or derivatives of any form.
This prohibition is structural, not regulatory. These instruments are the primary vehicles for speculative amplification in traditional markets. Removing them at the architectural level, rather than prohibiting them through enforceable rules (which can be circumvented), is the correct design choice. The blockchain implementation makes compliance automatic: the smart contract simply cannot execute these transaction types.

E.5 Equilibrium Model

E.5.1 General Equilibrium Condition

The PHREVO-Exchange is in general equilibrium when three conditions simultaneously hold:

Condition 1 — Market clearing for each token:

D(i,t) [P(i,t)] = X(i,t) [P(i,t)] for all i

Condition 2 — Consistency of total resource distribution:

SUM_i [P(i,t) * Q(i,t)] <= R(t) + M(t)

Where M(t) is the Community Liquidity Fund balance. The total market capitalization of all tokens cannot exceed real available resources plus liquidity reserves.

Condition 3 — Anti-speculation constraints hold:

q(a,i,t) / Q(i,t) <= lambda_i for all a, i, t

Age(a,i,t) >= M_a for all a, i, t (for sales)

P(i,t) <= P_max(i,t) for all i, t

E.5.2 Existence of Equilibrium

Theorem 1 *(Existence of Equilibrium)*

Under assumptions S1-S4 and the price formation mechanism of Section E.3, the PHREVO-Exchange has at least one Nash equilibrium in prices and quantities.

Proof sketch:

Step 1: The fundamental value function V(i,t) is continuous and non-decreasing in S(i,t) and R(t). Given that S(i,t) and R(t) are exogenous in the short run (determined by the PHREVO-Score verification process and fiscal/community policy), V(i,t) is a fixed parameter for each period.

Step 2: The aggregate demand D(i,t)(P) is a piecewise decreasing function, right-continuous on [P_min, P_max], where P_min = V(i,t)(1-delta_min) and P_max = min(V(i,t)(1+delta_max), P_max(i,t)).

Step 3: The aggregate supply X(i,t)(P) is constant (tokens issued are fixed within the period, except for emergency issuances) up to P_max, where it may increase through new token issuance via the liquidity fund.

Step 4: By Brouwer's Fixed Point Theorem applied to the excess demand correspondence on the compact set [P_min, P_max], there exists at least one P*(i,t) in [P_min, P_max] such that D(i,t)(P*) = X(i,t)(P*).

Step 5: At P*(i,t), the anti-speculation constraints hold by construction. Holding limits and maturation periods operate as participation constraints that, for atomistic agents, do not affect the price equilibrium. QED.

Economic interpretation: The Exchange has an equilibrium because the price corridor and the community floor prevent the instability typical of speculative markets. There are no "bubbles" because price is anchored to the fundamental value. There is no "liquidity trap" because the Community Liquidity Fund provides institutional demand at the floor.

E.5.3 Stability of Equilibrium

Theorem 2 *(Asymptotic Stability)*

The equilibrium characterized in Theorem 1 is asymptotically stable under Walrasian tatonnement price adjustment (price rises when there is excess demand, falls when there is excess supply) within the price corridor.

Proof sketch: Under Walrasian adjustment, the price path P(i,t+1) = P(i,t) + epsilon * (D(i,t) - X(i,t)) converges to equilibrium for small epsilon because: (1) D is strictly decreasing in P within the corridor; (2) X is non-decreasing; (3) the excess demand function is therefore strictly decreasing, guaranteeing unique intersection and stability. The corridor bounds prevent the reflexive feedback loops (price rises because price rises) that drive instability in speculative markets. QED.

E.5.4 Comparative Statics

E.6 Liquidity and Secondary Market

E.6.1 The Liquidity Problem Without Speculation

Traditional markets obtain liquidity through speculators: actors who buy expecting to sell at a higher price. Remove speculators and you remove the mechanism that makes continuous trading possible. This is why every previous social impact exchange has been illiquid — the actors who should participate (mission-aligned investors) are too few and too long-term to provide the continuous market that allows exit when needed.

PHREVO resolves this through three non-speculative liquidity layers that together approximate the liquidity function of speculative markets without their destabilizing properties:

E.6.2 Automated Market Maker With Price Bands

The secondary market uses an Automated Market Maker (AMM) similar in structure to Uniswap v3 concentrated liquidity, but with fundamental-value-anchored price bands:

P_AMM(i,x) = V(i,t)_base * [1 + beta * (x - x_eq) / x_max]

Where x is the token balance in the liquidity pool; x_eq is the equilibrium balance (when P = V_base); x_max is the balance at which price reaches the upper corridor bound; beta = 0.5 is the price sensitivity to imbalance (calibrated to minimize spread while maintaining stability).

Price band enforcement:

If P_AMM > V_base * (1 + delta_max): the AMM stops selling (only buys). This prevents price from exceeding the corridor ceiling through AMM operations.

If P_AMM < V_base * (1 - delta_min): the AMM stops buying (only sells). The Community Liquidity Fund then activates as the buyer of last resort.

Liquidity providers are community funds and cooperatives — not individual speculators. They deposit tokens and PHREVO currency into the pool in exchange for transaction fees (0.5% per trade, distributed proportionally to liquidity provision). This fee is low enough to not discourage trading, high enough to compensate liquidity providers for their commitment.

E.6.3 Community Liquidity Fund (CLF)

When the AMM cannot operate because the price is at the floor and there are no buyers, the Community Liquidity Fund activates:

Mission: purchase tokens at the floor price P = V(i,t) * (1 - delta_min) when there is persistent excess supply.

Resources: funded from 10% of total resources R(t) — not from external investors. The CLF is a structural component of the PHREVO economy, not a discretionary bailout mechanism.

Governance: purchase and sale decisions are algorithmic (rule-based), but supervised by the relevant territorial assembly. Transparency is complete — all CLF operations are recorded on the public blockchain.

Holding limit: the CLF cannot hold more than 30% of the tokens of any project. This prevents the CLF from becoming a de facto majority owner.

Orderly disposition: when prices recover to the upper corridor, the CLF may sell — but no more than 10% of its holdings per month to avoid destabilizing the recovery.

Operational example: Project A tokens are at the floor (20 PH). Sell orders exist for 5,000 tokens. The CLF algorithm verifies the floor condition and its own holding limit, purchases up to 3,000 tokens (the remaining 2,000 sell orders are not executed — sending a signal to the project that it must improve its Score or adjust expectations). The purchased tokens are held until prices recover.

E.6.4 Continuous Primary Market and Dilution Control

Projects needing continuous financing (beyond the initial issuance) may access quarterly VCG auctions for additional token issuance, subject to:

Updated impact report with verified PHREVO-Score (no score, no issuance).

Dilution limit: no more than 25% of total outstanding tokens may be newly issued in any 12-month period.

Assembly veto: the territorial assembly may block additional issuances if the project is not meeting impact targets, as determined by the Score trend and community audit.

E.7 Response to Shocks and Crises

E.7.1 Automatic Stabilization Mechanism

E.7.2 Circuit Breakers

E.7.3 System Resilience Fund (SRF)

The System Resilience Fund is the macro-stabilization backstop, separate from the CLF:

Source: 1% of all resources R(t) annually (1% of "PHREVO GDP") plus external donations designated for system resilience.

Target size: sufficient to cover 3 months of full Exchange operation (estimated at 15-20% of annual R(t)).

Activation: only by PHREVO Global Assembly decision with 75% supermajority. Cannot be activated by any single territorial assembly or operational team.

Permitted uses: purchase tokens in systemic crises (not single-project crises); provide emergency liquidity when both AMM and CLF are exhausted; subsidize transition of projects that lose Score due to external shocks (not internal failure) but have credible recovery plans.

E.8 Monte Carlo Simulation

E.8.1 Simulation Parameters

To test the model's behavior, a Monte Carlo simulation was conducted with the following parameters. Results are illustrative and require validation with real data before empirical deployment.

E.8.2 Results Across Scenarios

Interpretation of results:

In normal scenarios (optimistic and neutral), the Exchange operates with volatility comparable to traditional equity markets (12-18% annualized) but with substantially lower wealth concentration (top 10% hold 18-21% vs. 80%+ in traditional markets).

The shock scenario with stabilizers demonstrates the key design advantage: the crisis is absorbed in 8 months with price damage capped at approximately 30%. The CLF and circuit breakers prevent the reflexive sell-off that would otherwise amplify the shock.

The shock scenario without stabilizers confirms the model's necessity: without the CLF, circuit breakers, and SRF, a 30% resource shock produces a 67% annualized volatility, market illiquidity (15% spread), and permanent price collapse. This is the failure mode of all existing social impact exchanges.

E.8.3 Comparison With Traditional Markets

Principal conclusion of the simulation: The PHREVO-Exchange can achieve comparable volatility to traditional markets in normal conditions, responds to crises dramatically faster (8 months vs. 5 years), and produces substantially less permanent damage thanks to the automatic stabilizers and fundamental value anchoring. The critical design insight is that anchoring price to the PHREVO-Score and real resources — rather than to speculative expectations — does not sacrifice market efficiency; it redirects market dynamics toward genuine value discovery.

E.9 Limitations and Research Agenda

Recommended validation roadmap:

E.10 Conclusion and Invitation to Collaboration

This annex has presented a formal economic model for the PHREVO-Exchange — the first exchange architecture designed to simultaneously resolve the metric failure and the liquidity failure that have prevented the emergence of viable impact-based financial markets.

The model makes five substantive contributions to the market design literature:

A fundamental value function that anchors token prices to a verifiable impact metric and real redistributable resources, creating a market that prices genuine value rather than speculative expectation.

A price corridor mechanism that constrains speculation while preserving market flexibility, grounded in a formal proof of equilibrium existence and asymptotic stability.

Four structural anti-speculation constraints — holding limits, maturation periods, dynamic price ceiling, and complete prohibition of derivatives — that eliminate the primary mechanisms of speculative amplification without requiring continuous regulatory intervention.

A three-layer non-speculative liquidity solution that approximates the liquidity function of speculative markets without their destabilizing properties.

Monte Carlo simulation evidence that the PHREVO-Exchange achieves conventional market volatility in normal conditions while recovering from systemic crises in 8 months rather than the 5 years characteristic of unanchored speculative markets.

This model is a working paper, not a finished system. It requires rigorous peer review, agent-based simulation, and empirical calibration before deployment. PHREVO explicitly invites mathematical economists to stress-test the existence and stability theorems; market designers to propose alternative mechanisms or identify vulnerabilities; data scientists to run more realistic simulations; and regulators and academic economists to discuss the viability of a regulatory sandbox for small-scale empirical testing.

The question this annex answers is not "is the PHREVO-Exchange perfect?" — it is not. The question is "does a formal theoretical framework exist for an impact-based exchange without speculation?" The answer is yes. The framework is here. The invitation to critique, improve, and ultimately implement it is open.

References

Arrow, K.J., & Debreu, G. (1954). Existence of an Equilibrium for a Competitive Economy. Econometrica, 22(3), 265-290.

Clarke, E.H. (1971). Multipart Pricing of Public Goods. Public Choice, 11(1), 17-33.

Friedman, M. (1953). Essays in Positive Economics. University of Chicago Press.

Groves, T. (1973). Incentives in Teams. Econometrica, 41(4), 617-631.

Jimenez, A. (2026). PHREVO: A Post-Capitalist Economic Architecture for the Global South. SSRN Working Paper 6614438. DOI: 10.5281/zenodo.19666941.

Klemperer, P. (2004). Auctions: Theory and Practice. Princeton University Press.

Krishna, V. (2009). Auction Theory, 2nd Edition. Academic Press.

Milgrom, P. (2017). Discovering Prices: Auction Design in Markets with Complex Constraints. Columbia University Press.

Ostrom, E. (1990). Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press.

Radner, R. (1972). Existence of Equilibrium of Plans, Prices, and Price Expectations in a Sequence of Markets. Econometrica, 40(2), 289-303.

Samuelson, P.A. (1947). Foundations of Economic Analysis. Harvard University Press.

Shiller, R.J. (2000). Irrational Exuberance. Princeton University Press.

Stiglitz, J.E. (2010). Freefall: America, Free Markets, and the Sinking of the World Economy. Norton.

Vickrey, W. (1961). Counterspeculation, Auctions, and Competitive Sealed Tenders. Journal of Finance, 16(1), 8-37.

Walras, L. (1874). Elements d'Economie Politique Pure. L. Corbaz.

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