Solvable Market Hypothesis: Toward a Mathematical Theory of Market Predictability through Collective Behavior and Game Theory

Abstract

This paper introduces the **Solvable Market Hypothesis**, a theoretical framework proposing that financial markets are fundamentally mathematical systems governed by the aggregated behavior of individuals acting in pursuit of profit. The hypothesis draws from concepts in game theory, collective intelligence, and computational modeling to suggest that, while complex and difficult to calculate, the market may be in principle *solvable*, akin to a multi-agent dynamic game. Though the practical implementation remains constrained by current computational and behavioral modeling limitations, the theoretical implications are significant for understanding markets as deterministic, data-rich systems rather than chaotic, unpredictable entities.

1. Introduction

The idea originated from a philosophical and mathematical reflection: *What if financial markets, like games such as chess, are technically solvable systems?* While human psychology and external factors play undeniable roles in short-term volatility, the assumption here is that the **collective behavior** of market participants, each aiming for profit, creates a structured and quantifiable outcome over time.

This leads us to an intriguing claim: **The market is a dynamic, real-time, multi-agent game seeking equilibrium through the probabilistic movement of its components.** This paper lays out the foundational logic of this hypothesis and relates it to existing academic discourse.

2. Theoretical Foundations

2.1 Game Theory and Strategic Equilibria

Game theory provides a natural foundation for understanding how individual traders (agents) interact under conditions of uncertainty. Each trader aims to optimize returns based on available information, and their strategies are

interdependent. From a macro perspective, this produces probabilistic but patterned movements.

We draw inspiration from **Nash Equilibrium** and **evolutionary game theory**, which suggest that players, over time, tend toward strategies that stabilize based on aggregate interactions.

2.2 The Wisdom of the Crowd

This hypothesis assumes that markets act as large-scale information processing systems. According to the **collective wisdom principle**, under certain conditions, the average estimation or action of a crowd can be more accurate than that of any individual participant.

This suggests that while individual trades may be noisy or irrational, the aggregate movement of the market follows a deeper statistical logic—a signal hidden within the noise.

2.3 Integration Over Time

The core mathematical assumption here is that if we integrate the collective behavior of all agents over infinitesimally small time intervals, we can obtain a **converging series** or function that represents the market's future state trajectory.

This resembles how deterministic chaos or probabilistic models in quantum mechanics can, when scaled and averaged, reveal stable laws.

3. The Solvable Market Hypothesis

Hypothesis: If each market participant acts to maximize profit and responds dynamically to others' actions, the market becomes a high-dimensional system governed by a complex but solvable equation — a sequence or function that could theoretically predict future states with high probability.

This hypothesis is built on several key points:

1. **Every component moves toward profit** — akin to particles moving toward energy minima in physics.
2. **Movement is relative and interactive**, influenced by other components' trajectories.
3. **Aggregate behavior forms a predictable series** — though difficult to calculate with current tools.

Therefore, while the market appears chaotic, it may in fact be a solvable system masked by computational and informational limitations.

4. Comparison to Existing Models

While elements of this idea appear in models like: - **Efficient Market Hypothesis (EMH)** — assuming prices reflect all known information. - **Random Walk Theory** — stating that prices follow an unpredictable path. - **Agent-Based Modeling** — simulating markets via individual decision rules.

...none of these treat the market explicitly as a *solvable game-theoretic system*. The Solvable Market Hypothesis bridges this gap, suggesting the market is not random but merely difficult to solve due to variable overload.

5. Practical Implications and Limitations

This is currently a *theoretical construct*. In practice, it faces obstacles: - Vast number of variables - Unpredictability of external shocks - Computational limitations - Limited understanding of emergent behavior

Yet, the **value of the hypothesis** lies in its unifying perspective: *The market may be mathematically predictable, if not practically solvable (yet).* It pushes forward the idea that financial systems are not beyond reason but simply beyond reach — for now.

6. Conclusion and Future Work

The Solvable Market Hypothesis reframes the market from an unpredictable beast to a sophisticated, data-driven structure awaiting the right computational breakthroughs. It encourages new directions in algorithmic economics, artificial intelligence, and multi-agent modeling.

The author acknowledges that proving or applying this hypothesis is far beyond their current capabilities and outside their primary field. However, this document is intended as an intellectual timestamp of the idea, in the spirit of open science and future curiosity.

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Status: Theoretical Idea, Solo Research Basis
Date: August 3, 2025