International Journal of Finance, Economics, and Management Studies
ISSN: 3108-0030 | Volume 1 Issue 2, 41-46, October-December 2025
DOI: https://doi.org/10.64137/31080030/IJFEMS-V1I2P106

Received: 17/10/2025 Revised: 28/10/2025 Accepted: 06/12/2025 Published: 16/12/2025

Original Article

Quantum Economics: Reframing Value, Scarcity, and Exchange in the Digital Age

DR. PITSHOU MOLEKA
Managing African Research Network (MARN), Kinshasa, Democratic Republic of the Congo.

ABSTRACT: *This paper introduces Quantum economics as a post-classical economic paradigm capable of explaining value formation, exchange dynamics, and behavioural change in digital environments. Traditional economic assumptions inherited from classical and neoclassical frameworks fail to capture the dynamics of twenty-first-century markets, which are dominated by intangible assets, algorithmic trading, platform monopolies, and network-driven value creation. Drawing on principles from quantum theory including uncertainty, entanglement, superposition, relational statehood, and wave-function collapse this paper develops a conceptual and empirical model of economic reality that treats value probabilistically, contextualises identity, and recognises relational dependencies. The digital economy exemplifies structural uncertainty, non-linear cascading dynamics, network amplification, and valuation processes governed by expectations rather than intrinsic scarcity. By synthesising evidence from high-frequency finance, cryptocurrency valuation, data markets, and behavioural psychology, this article demonstrates that economic systems in the digital age operate as quantum information systems rather than classical mechanical systems. Comparative tables are developed to contrast classical and quantum economic assumptions and to map digital market phenomena to quantum concepts. The paper concludes by outlining a research programme integrating complexity theory, network mathematics, and behavioural macroeconomics, proposing Quantum Economics as a foundational paradigm for twenty-first-century economic science.*

KEYWORDS: *Quantum economics, Digital value, Scarcity, Innovation, Entanglement, Network theory, Information markets.*

1. INTRODUCTION

Economics as a discipline has historically been constructed on Newtonian metaphors, privileging concepts such as stability, equilibrium, separability, and deterministic causality. These assumptions were appropriate during the industrial age, when economies were defined by material scarcity, rival goods, and predictable production processes, such as the production of steel, coal, and agricultural commodities (Friedman, 1953; Samuelson, 1947). Under these conditions, classical and neoclassical frameworks provided robust predictive and normative tools. Price mechanisms could be modeled deterministically, individual agents could be treated as self-contained decision-makers with fixed utility functions, and the temporal unfolding of economic activity could be approximated as linear and continuous.

The digital revolution has fundamentally transformed the economic landscape, rendering these classical assumptions increasingly inadequate. Modern economies are characterized by intangible assets, algorithmic processes, digital platforms, social networks, and anticipatory expectations. Goods and services often replicate at near-zero marginal cost, and data ubiquitous, networked, and combinatorial—produces exponential returns. Cryptocurrencies and digital tokens derive their value less from physical scarcity and more from collective belief systems, social consensus, and algorithmically mediated expectations. Prices in these markets fluctuate at millisecond or microsecond intervals, driven by high-frequency trading and automated decision-making, far beyond the cognitive and temporal capacities of human agents (Kirilenko et al., 2017).

Simultaneously, digital platforms generate cascading social feedback loops, wherein attention, sentiment, and collective perception actively shape economic outcomes. This observer-dependence mirrors phenomena observed in quantum systems, where measurement itself affects state evolution (Zuboff, 2019). In such contexts, traditional assumptions of separability, linearity, and determinism break down. Individuals are no longer stable, self-contained utility-maximizing agents; their preferences and roles are fluid, context-dependent, and relational. Market outcomes are emergent, path-dependent, and influenced by multi-level interactions across social and technological networks.

Quantum Economics posits that these deviations are not anomalies but instead reflect the fundamental ontological nature of contemporary economies. Economic systems in the digital era are probabilistic rather than deterministic, with value distributed across relational networks. Uncertainty is structural, not merely informational, and agents exhibit multi-layered, superposed identities that occupy simultaneous roles as creators, consumers, investors, and data producers. Exchange outcomes depend on observation, narrative framing, and collective expectation. By integrating principles from quantum theory, network science, and complexity theory, Quantum Economics offers a rigorous post-classical paradigm for understanding value creation, allocation, and decision-making in digital markets, positioning the field as an empirically grounded framework rather than a metaphorical analogy.

2. LIMITATIONS OF CLASSICAL AND NEOCLASSICAL ECONOMICS IN DIGITAL ENVIRONMENTS

Classical and neoclassical economic theories are fundamentally rooted in the assumptions of scarcity, equilibrium-seeking behavior, rational choice, and diminishing marginal returns. These assumptions presuppose that economic goods are rival and excludable, that individuals make consistent, utility-maximizing decisions, and that market forces tend toward equilibrium over time. While these models provide predictive power for traditional industrial economies, they struggle to describe modern digital markets characterized by non-rival knowledge, network effects, and identity-driven behavioral dynamics.

Knowledge is a paradigmatic non-rival good: once created, it can be reproduced indefinitely without depletion or loss of utility (Foray, 2004). Software firms, digital platforms, and open-source ecosystems exemplify near-zero marginal costs and exponential scalability, challenging the marginalist notion that price is strictly tied to production costs. Equilibrium models fail to capture cryptocurrency valuation dynamics, platform monopolies, and network-driven exponential growth. Bitcoin, for example, has repeatedly surpassed valuations of one trillion U.S. dollars, despite lacking intrinsic physical or commodity backing (Baur et al., 2018). Similarly, multinational technology platforms such as Apple and Google maintain multi-trillion-dollar valuations not through physical capital, but through complex informational ecosystems, network effects, and culturally mediated value generation.

Behavioural economics has highlighted that human decision-making is influenced by social identity, emotional states, framing effects, and contextual uncertainty (Kahneman, 2011). However, even these approaches retain classical ontological commitments, assuming linear cognitive biases and separable agents rather than embracing systemic entanglement, relational dependencies, and superposed identities. Classical economic frameworks, while still informative for agricultural or commodity markets, cannot account for viral information diffusion, the proliferation of tokenized assets, or the relational nature of networked value creation.

TABLE 1 Classical vs. quantum economic ontologies

Dimension	Classical Economics	Quantum Economics
Ontology	Atomistic agents	Entangled relational agents
Value Basis	Scarcity and production cost	Information, networks, meaning
Identity	Fixed utility functions	Multi-state identity superposition
Market Dynamics	Equilibrium seeking	Non-linear probability evolution
Information	Perfect or asymmetric	Ontologically uncertain
Price Behaviour	Deterministic fundamentals	Probabilistic expectation waves
Time	Linear	Temporal decoherence and jumps
Exchange	Rival goods	Non-rival digital reproduction

2.1. COMMENTARY ON TABLE 1

This table captures the fundamental shift in economic ontology required for analyzing digital and post-industrial markets. Classical economics assumes that agents are discrete and separable; value is rooted in scarcity and production costs, and market dynamics tend toward equilibrium. By contrast, Quantum Economics conceptualizes agents as relational and entangled, meaning is co-constructed across networks, and identities exist in superposition across multiple economic roles. Market behavior is non-linear, and price is probabilistic, reflecting the anticipatory, context-dependent expectations of networked participants rather than deterministic cost fundamentals. Time itself is no longer strictly linear; digital economies exhibit temporal decoherence and abrupt discontinuities, such as flash crashes, that classical models cannot predict. Finally, exchange in digital markets often involves non-rival goods, whose replication does not deplete their utility, fundamentally undermining scarcity-based pricing assumptions. The table is thus not merely descriptive but provides a framework for rethinking the modeling, policy design, and empirical analysis of twenty-first-century economic systems.

3. QUANTUM THEORY FOUNDATIONS APPLIED TO ECONOMIC SYSTEMS

Quantum physics has fundamentally altered our understanding of reality, demonstrating that physical systems are inherently probabilistic rather than deterministic. Quantum states are described by wave functions that encode probability distributions over potential outcomes, and observation itself collapses these probability amplitudes into realised states (Bohr, 1935; Dirac, 1930; Heisenberg, 1930). This ontological insight provides a powerful lens for understanding the behaviour of contemporary digital economies, where value is relational, expectation-driven, and context-dependent rather than intrinsic and fixed.

In digital markets, cryptocurrencies exemplify this phenomenon. The valuation of a cryptocurrency such as Bitcoin or Ethereum is determined less by material or intrinsic backing and more by social narratives, community beliefs, and collective expectations. Market prices, therefore, resemble quantum amplitude functions: they exist in multiple potential states simultaneously, oscillating according to collective sentiment, until a moment of observation manifested through trading activity, platform intervention, or regulatory signals collapses the system into a realised price outcome (Baur et al., 2018; Kirilenko et al., 2017). The market outcome is inherently relational, contingent upon the interactions of agents within networked environments, rather than solely reflecting scarcity or production costs as classical economics would predict.

Quantum entanglement further illuminates the structural interdependencies of digital markets. In quantum physics, entangled particles maintain correlations across distances, regardless of direct interaction. Analogously, financial and digital asset networks exhibit entanglement: the price movements of assets in one market can be systematically correlated with distant markets, even in the absence of direct transactions (Baur et al., 2018; Kirilenko et al., 2017). Network effects, systemic interconnections, and algorithmic arbitrage generate correlations that classical separability assumptions cannot capture.

Quantum superposition, in which a system simultaneously occupies multiple states, provides a useful analogy for contemporary digital identities. Individuals and economic actors in digital ecosystems simultaneously function as content creators, consumers, investors, social influencers, and data producers. These overlapping roles create complex, interdependent behavioural patterns that cannot be reduced to a single, coherent utility function. Critically, these correspondences are not merely metaphorical; empirical observations of multi-functional agent behaviour, algorithmic trading, and platform-mediated interactions demonstrate that digital economies operate structurally as entangled, superposed systems.

By applying quantum principles to economic modelling, analysts can better account for the relational, probabilistic, and context-dependent nature of value formation in digital environments. This approach challenges the assumption that prices reflect intrinsic scarcity or that agents behave as independent, stable optimisers. Instead, value emerges from the superposition of multiple potential states, entangled across networks, and observed through collective action.

4. SUPERPOSITION AND IDENTITY IN DIGITAL MARKETS

Classical economic theory treats agents as singular, stable entities with coherent and consistent preferences. Bounded rationality theory recognises cognitive limits (Simon, 1957), yet it still assumes that agents operate with a single, optimisable function. Digital economies challenge this notion fundamentally. Economic identity in digital markets is dynamic, multi-layered, and simultaneously occupied across multiple functions. For example, an individual may produce monetised content on social media, invest in cryptocurrency, work remotely for a foreign firm, and generate behavioural data for targeted advertising all at the same time.

This multiplicity directly parallels the quantum principle of superposition, wherein a particle exists in multiple states until observed. In economic terms, digital agents exist in overlapping functional states, with market outcomes emerging from the collective interaction of these superposed roles rather than from a single, intrinsic objective.

Cryptocurrencies themselves demonstrate superposed economic states. Bitcoin is simultaneously a speculative asset, a digital commodity, a cultural meme, and a macroeconomic hedging instrument. Its market price does not arise from any singular state but from the interaction of these multiple co-existing interpretations and expectations. Observed price emerges only when collective market action “collapses” the multiplicity of potential valuations into a realised outcome, highlighting the probabilistic and expectation-driven nature of modern value formation. Table 2 below maps key quantum phenomena to observable behaviours in digital economic systems, highlighting the structural relevance of quantum concepts for economic analysis.

TABLE 2 Quantum phenomena mapped to digital market behaviour

Quantum Concept	Digital Economic Behaviour
Entanglement	Network effects and platform dependency, where actions in one node influence distant nodes without direct exchange (Baur et al., 2018)
Superposition	Multi-functional asset or agent identity, such as cryptocurrencies acting as commodity, speculative asset, and cultural meme simultaneously
Wave collapse	Market price formation occurring when expectation, narrative, or observation crystallises potential states into a realised outcome
Uncertainty	Irreducible volatility inherent in data-driven markets, reflecting structural unpredictability rather than informational gaps
Tunnelling	Flash crashes and non-continuous price jumps that occur without classical market causality (Kirilenko et al., 2017)
Decoherence	Sudden breakdown of consensus or coordination in markets, leading to abrupt transitions in value and network behaviour

Commentary: This mapping illustrates that quantum principles are structurally embedded in modern digital economic systems. Entanglement captures relational dependencies; superposition represents multi-dimensional agent and asset identities; wave collapse models the contextual formation of market prices; uncertainty captures irreducible volatility; tunnelling reflects non-linear discontinuities; and decoherence accounts for systemic disruptions. Collectively, these correspondences provide a robust framework for understanding digital markets as probabilistic, networked, and contextually emergent systems, in stark contrast to the deterministic, atomistic assumptions of classical economics.

5. ENTANGLEMENT AND NETWORK VALUE FORMATION

Quantum entanglement demonstrates that particles do not possess independent states but exist relationally, such that the state of one particle instantaneously influences another regardless of distance (Einstein, Podolsky, & Rosen, 1935). This principle offers a structural lens to understand digital platform economies. In networked markets, the value of an asset or service emerges not from its intrinsic properties but through relational interdependencies across participants. User engagement on platforms, for example, increases utility and perceived value for others even without direct interaction, creating a networked amplification of value that classical individualistic assumptions cannot capture.

Metcalfe's law formalises this phenomenon, showing that the value of a network grows quadratically with the number of participants (Metcalfe, 2013). Similarly, Arthur's (1999) framework of increasing returns illustrates that network effects and positive feedback loops can dominate market dynamics, creating path dependence, concentration of influence, and non-linear value creation. In digital economies, these dynamics are evident in the adoption of social networks, blockchain ecosystems, and peer-to-peer platforms, where the participation of each additional user increases relational utility and indirectly shapes prices, liquidity, and market expectations.

This relational perspective fundamentally challenges classical equilibrium models. Traditional economic theory assumes independent agents operating in separable, mechanistic markets where prices converge toward equilibrium based on supply and demand. By contrast, network entanglement in digital economies produces emergent, non-linear outcomes where the value of individual nodes is inseparable from the behaviour of the system as a whole. These relational dynamics necessitate a rethinking of market theory, incorporating network science, field-theoretic approaches, and probability-based modelling to capture value formation as a systemic, interdependent process.

6. UNCERTAINTY AS FUNDAMENTAL

Knight (1921) distinguished between risk, which is quantifiable, and uncertainty, which is inherently unknowable. Classical economics treats uncertainty as largely informational: better knowledge reduces unpredictability. Digital economies, however, reveal that uncertainty is structural, not merely informational. Cryptocurrencies, algorithmic trading, and data-driven markets remain highly volatile even under conditions of near-perfect transparency. This suggests that unpredictability is an emergent property of the system rather than a temporary deficit of information.

Empirical evidence from flash crashes and high-frequency trading underscores the limits of deterministic forecasting. In 2010, the U.S. stock market experienced a flash crash in which the Dow Jones Industrial Average dropped nearly 1,000 points within minutes, only to partially recover immediately thereafter (Kirilenko et al., 2017). Such events are analogous to quantum tunnelling, where a particle crosses an energy barrier without following classical trajectories. Similarly, sudden liquidity collapses, algorithm-driven feedback loops, and rapid shifts in sentiment illustrate that volatility in digital markets is irreducible and systemic. Consequently, economic models must incorporate structural uncertainty, probabilistic evolution, and contextual dependencies rather than assuming equilibrium convergence or linear adjustment.

7. IMPLICATIONS FOR ECONOMIC THEORY AND MODELLING

Quantum Economics necessitates a profound revision of foundational economic assumptions. Rational choice theory, grounded in stable, atomistic agents and utility maximisation, must give way to contextual identity models that accommodate multi-state, superposed agents interacting relationally across complex networks. Monetary theory should reconceptualise currency as informational and socially constructed, with value emerging from relational trust, network participation, and expectation formation rather than physical commodity backing.

Market modelling must adopt probability amplitudes and stochastic, non-linear approaches in place of deterministic supply-demand curves. Network entanglement implies that policy interventions, such as breaking up platform monopolies, may inadvertently destroy relational value embedded in user interactions, highlighting the need for nuanced regulatory frameworks that account for systemic dependencies. Bayesian quantum decision theory offers a promising methodological foundation, formalising decision-making under relational uncertainty and multi-state identity while integrating probabilistic inference with expectation-driven valuation (Busemeyer & Bruza, 2012). These implications extend across financial markets, digital platforms, and innovation ecosystems. Policymakers, regulators, and scholars must recognise that traditional models of risk, equilibrium, and rational optimisation are insufficient for predicting or managing twenty-first-century economic phenomena.

Instead, embracing a quantum-informed framework allows for more accurate modelling of emergent behaviour, network effects, and multi-functional agents.

8. FUTURE DIRECTIONS AND RESEARCH AGENDA FOR QUANTUM ECONOMICS

Quantum Economics opens multiple avenues for theoretical refinement, empirical validation, and practical application. Future research should focus on the following key areas.

8.1. QUANTUM-INFORMED MARKET MODELLING

Develop stochastic, network-based models that integrate superposition, entanglement, and probabilistic price dynamics. Agent-based simulations can capture multi-layered identity and contextual decision-making in digital ecosystems (Busemeyer & Bruza, 2012; Farmer & Foley, 2009).

8.2. ALGORITHMIC AND AI-DRIVEN ECONOMIES

Investigate how machine learning, autonomous trading systems, and predictive algorithms operate within entangled, probabilistic markets. Assess the impact of algorithmic decision-making on market volatility, emergent behaviour, and systemic risk (Narayanan et al., 2016).

8.3. BEHAVIORAL AND RELATIONAL IDENTITY STUDIES

Empirically explore multi-state agent behaviour in digital markets, focusing on overlapping roles such as creator, consumer, investor, and data producer. Examine how relational networks shape valuation, preferences, and expectation formation (Camerer, 2003; Kahneman, 2011).

8.4. POLICY AND GOVERNANCE IMPLICATIONS

Design regulatory frameworks that account for structural uncertainty, network entanglement, and emergent relational value. Investigate the trade-offs of platform interventions, decentralisation, and tokenised governance in mitigating systemic risk (Zetzsche et al., 2020).

8.5. QUANTUM ECONOMICS OF INNOVATION AND KNOWLEDGE

Extend the framework to knowledge-intensive sectors, examining how superposed identities and network effects drive innovation, diffusion, and adoption of new technologies (Romer, 1990; Foray, 2004).

8.6. INTERDISCIPLINARY METHODOLOGIES

Integrate insights from complexity science, network mathematics, cognitive psychology, and quantum information theory to create a unified methodological toolkit for analysing digital economies (Arthur, 1999; Busemeyer & Bruza, 2012).

9. CONCLUSION

The digital economy exhibits probabilistic, relational, and multi-layered behaviour analogous to principles observed in quantum systems. Classical economic frameworks are unable to account for phenomena such as network entanglement, superposed agent identity, zero-marginal-cost goods, and cryptocurrency valuation. Quantum Economics offers a rigorous post-classical paradigm, grounded in empirical observation, network science, and complexity theory, capable of reconceptualising value, scarcity, and exchange in the twenty-first century.

By framing economic interactions as probabilistic, relational, and context-dependent, Quantum Economics provides a foundational framework for modelling digital market behaviour, understanding emergent value creation, and informing policy in an era dominated by intangible assets, algorithmic dynamics, and networked economies. This paradigm shift establishes the theoretical and empirical basis for a new economics that reflects the realities of the digital age, advancing both academic understanding and practical economic governance.

REFERENCES

[1] W. Brian Arthur, “Complexity and the Economy,” Science, vol. 284, no. 5411, pp. 107-109, April 1999.

[2] Dirk G. Baur, KiHoon Hong, and Adrian D. Lee, “Bitcoin: Medium of Exchange or Speculative assets?” Journal of International Financial Markets, Institutions and Money, vol. 54, no. 1, pp. 177–189, May 2018.

[3] N. Bohr, “Can quantum-mechanical description of reality be complete?” Physical Review, vol. 48, pp. 696-702, October 1935.

[4] Jerome R. Busemeyer, and Peter Bruza, “Quantum Models of Cognition and Decision: Principles and Applications,” 2nd ed., Cambridge University Press, Cambridge, UK, pp. 1-456, 2012, 2025.

[5] C. Camerer, “Behavioral game theory: Experiments in Strategic Interaction,” Princeton University Press, 2003.

[6] P. A. M. Dirac, “The principles of quantum mechanics,” Oxford University Press, 1930.

[7] A. Einstein, B. Podolsky, and N. Rosen, “Can quantum-mechanical description of physical reality be complete?” Physical Review, vol. 47, pp. 777-780, 1935.

[8] J. D. Farmer, and D. Foley, "The Economy needs Agent-based Modelling," Nature, vol. 460, no. 7256, pp. 685-686, 2009.

[9] Dominique Foray, "The Economics of Knowledge," MIT Press, pp. 1-275, 2004.

[10] M. Friedman, "Essays in Positive Economics," Chicago University Press, 1953.

[11] W.K. Heisenberg, "The Physical Principles of Quantum Theory," University of Chicago Press, pp. 15-19, 1930.

[12] D. Kahneman, "Thinking, Fast and Slow," Farrar, Straus and Giroux, 2011.

[13] A. Kirilenko et al., "The Flash Crash: High-Frequency Trading in an Electronic Market," Journal of Finance, vol. 72, no. 3, pp. 967-998, 2017.

[14] F.H. Knight, "Risk, Uncertainty, and Profit," Houghton Mifflin, 1921.

[15] B. Metcalfe, "Metcalfe's law after 40 years of Ethernet," Computer, vol. 46, no. 12, pp. 26-31, 2013.

[16] A. Narayanan et al., "Bitcoin and Cryptocurreancy Technologies: A Comprehensive Introduction," Princeton, NJ: Princeton University Press, 2016.

[17] P.M. Romer, "Endogenous Technological Change, Journal of Political Economy, vol. 98, no. 5, pp. S71-S102, 1991.

[18] P.A. Samuelson, "Foundations of Economic Analysis," Harvard University Press, Cambridge, 1947.

[19] H. A. Simon, "Models of Man: Social and Rational: Mathematical Essay on Rational Human Behavior in Society Setting," New York, NY: Wiley, 1957.

[20] D.A. Zetzsche et al., "The Rise of Digital Finance: Challenges and Opportunities for Regulation," *University of Illinois Law Review*, vol. 5, pp. 1357–1415, 2020.

[21] Shoshana Zuboff, The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power," New York, Public Affairs, pp. 1-704, 2019.