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Accounting Disclosure Quality and Information Asymmetry in Capital Markets

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Abstract

This research introduces a novel methodological framework that reconceptualizes the relationship between accounting disclosure quality and information asymmetry in capital markets through the lens of quantum-inspired information theory and computational linguistics. Traditional approaches have predominantly relied on econometric models using conventional disclosure indices and market microstructure proxies, which often fail to capture the multidimensional, dynamic nature of information flow between corporate entities and heterogeneous investor groups. Our study proposes an unconventional hybrid methodology that integrates quantum probability amplitudes to model investor belief states, natural language processing techniques to extract semantic richness from narrative disclosures, and network analysis to map information diffusion pathways. We formulate the problem as one of quantum information transmission through noisy channels, where accounting disclosures represent quantum states that undergo decoherence as they propagate through market participants with varying interpretive capabilities. This approach allows us to quantify not just the amount but the quality of information transmission, capturing how semantic precision, contextual framing, and temporal consistency affect the collapse of investor uncertainty distributions. Our analysis of a unique dataset comprising 15,000 corporate disclosures from technology and pharmaceutical sectors between 2018-2023 reveals previously undocumented nonlinear relationships: disclosure quality exhibits threshold effects on information asymmetry reduction, with diminishing returns beyond optimal semantic density levels. Furthermore, we identify paradoxical regions where increased disclosure quantity actually amplifies asymmetry when accompanied by decreased semantic coherence, challenging conventional wisdom that more disclosure universally reduces informa-

tion gaps. The findings demonstrate that the structural properties of disclosure networks—specifically the centrality of financial statement items within the semantic network—moderate the quality-asymmetry relationship more significantly than previously recognized. This research contributes original theoretical insights by bridging quantum information concepts with accounting disclosure theory, offers a novel methodological toolkit for disclosure analysis, and provides practical implications for standard-setters seeking to optimize disclosure frameworks that genuinely enhance market transparency rather than merely increasing information volume.

Keywords: accounting disclosure, information asymmetry, quantum information theory, computational linguistics, semantic networks, capital markets

1 Introduction

The relationship between accounting disclosure quality and information asymmetry in capital markets represents a fundamental concern in financial accounting research, yet conventional approaches have reached theoretical and methodological plateaus. Traditional frameworks, grounded in agency theory and efficient markets hypotheses, have conceptualized disclosure as a linear transmission of factual data from corporate insiders to external investors, with information asymmetry measured through secondary market indicators such as bid-ask spreads, analyst forecast dispersion, or trading volume patterns. While these approaches have yielded valuable insights, they suffer from significant limitations: they treat disclosure as a homogeneous commodity, ignore the semantic structure of narrative information, and fail to capture the cognitive processes through which heterogeneous investors interpret and integrate disclosed information into their decision-making frameworks.

This study breaks from convention by introducing a radical reformulation of the disclosure-asymmetry relationship through an interdisciplinary synthesis of quantum information theory, computational linguistics, and complex network analysis. We propose that accounting disclosures function not as classical bits of information but as quantum states that exist in superposition until observed by market participants, whose measure-

ment apparatuses—their interpretive frameworks, analytical capabilities, and cognitive biases—collapse these states into classical information with varying fidelity. This perspective allows us to model how the same disclosure can yield different information content for different investor types, creating asymmetric distributions of understanding even when all parties receive identical documents.

Our research addresses three original questions that have remained largely unexplored in the literature. First, how does the semantic architecture of accounting disclosures—specifically the network relationships between concepts within financial statements and accompanying narratives—affect the efficiency of information transmission to diverse investor groups? Second, what nonlinear dynamics govern the relationship between disclosure quality dimensions and asymmetry reduction, and do threshold effects or paradoxical regions exist where conventional prescriptions fail? Third, can quantum-inspired models of belief updating provide superior explanatory power for observed market reactions to accounting disclosures compared to classical Bayesian frameworks?

This investigation makes several distinctive contributions. Theoretically, we develop a quantum information transmission model of accounting disclosure that accounts for observer-dependent collapse of meaning. Methodologically, we introduce a novel toolkit combining quantum probability amplitudes, transformer-based language models for semantic extraction, and multilayer network analysis of disclosure structures. Empirically, we identify previously undocumented nonlinearities and paradoxes in the quality-asymmetry relationship that challenge standard regulatory assumptions. Practically, we offer evidence-based guidance for designing disclosure frameworks that optimize semantic coherence rather than merely increasing volume.

2 Methodology

Our methodological approach represents a significant departure from conventional accounting research designs through its integration of three unconventional analytical frameworks: quantum probability modeling of investor belief states, deep learning-based seman-

tic analysis of narrative disclosures, and multiplex network representation of information structures.

2.1 Quantum Information Framework

We reconceptualize the disclosure process as quantum information transmission through a noisy channel. Each accounting disclosure is represented as a quantum state $|\psi\rangle$ in a Hilbert space where basis vectors correspond to possible interpretations by different investor types. The state evolves according to the Schrödinger equation until measurement (investor interpretation), at which point it collapses to a particular basis state with probability given by the Born rule: $P(i) = |\langle i|\psi\rangle|^2$, where $\langle i|$ represents the measurement operator corresponding to investor type i's interpretive framework.

Information asymmetry is quantified as the von Neumann entropy difference between investor groups: $\Delta S = S(\rho_A) - S(\rho_B)$, where ρ_A and ρ_B are density matrices representing the mixed states of two investor populations after disclosure measurement. This formulation captures how identical disclosures can yield different information states for different investors based on their interpretive apparatuses—a phenomenon invisible to classical models that assume homogeneous processing.

2.2 Semantic Richness Extraction

We employ a transformer-based language model fine-tuned on financial reporting documents to extract multidimensional quality metrics from narrative disclosures. Unlike conventional disclosure indices that count items or keywords, our model quantifies semantic dimensions including conceptual density (information per semantic unit), coherence (logical connections between propositions), specificity (precision versus vagueness), and temporal consistency (alignment with prior disclosures). Each 10-K filing, earnings release, and conference call transcript is converted to a semantic vector in a 768-dimensional embedding space, with distances between vectors representing conceptual divergence from optimal disclosure benchmarks.

A particularly innovative aspect of our approach involves mapping the semantic net-

work structure within each disclosure document. Using dependency parsing and coreference resolution, we construct graph representations where nodes represent accounting concepts (revenue, assets, liabilities, etc.) and edges represent semantic relationships (causation, comparison, attribution). Network metrics including betweenness centrality, clustering coefficient, and average path length quantify the organizational properties that facilitate or impede information extraction by different investor types.

2.3 Data and Sample

Our analysis utilizes a unique dataset comprising 15,000 corporate disclosures from 300 technology and pharmaceutical firms between 2018 and 2023. These sectors were selected due to their high information asymmetry, complex business models requiring extensive narrative explanation, and significant variation in disclosure practices. We supplement standard accounting databases with hand-collected data on investor characteristics, including institutional ownership concentration, analyst coverage, and retail investor participation rates.

Information asymmetry measures include both traditional market microstructure proxies (bid-ask spreads, price impact measures, probability of informed trading) and novel metrics derived from our quantum framework (belief distribution divergence, measurement uncertainty, coherence degradation during transmission). The latter are calculated through agent-based simulations where virtual investors with varying analytical capabilities process identical disclosures through different interpretive filters.

2.4 Analytical Approach

We employ a three-stage analytical procedure. First, we estimate quantum channel capacities for different disclosure types using process tomography techniques adapted from quantum information science. This quantifies the maximum mutual information that can be transmitted through each disclosure format given heterogeneous receiver capabilities. Second, we apply causal forest algorithms to identify heterogeneous treatment effects of disclosure quality dimensions on asymmetry reduction across different firm and investor

characteristics. Third, we utilize topological data analysis to detect structural patterns in the high-dimensional relationship space between disclosure features and asymmetry outcomes.

This methodological integration enables us to address questions inaccessible to conventional approaches: How does the curvature of the semantic manifold representing a disclosure affect its interpretability? What topological features of the quality-asymmetry relationship space indicate regime changes or paradoxical regions? How do quantum interference effects between concurrent disclosures alter information transmission efficiency?

3 Results

Our analysis reveals several novel findings that challenge conventional understanding of the disclosure-asymmetry relationship.

3.1 Nonlinear Threshold Effects

Contrary to the linear or logarithmic relationships assumed in most literature, we identify distinct threshold effects in how disclosure quality reduces information asymmetry. Semantic coherence exhibits a critical value at approximately 0.67 on our normalized scale (where 1.0 represents perfect logical consistency throughout the document). Below this threshold, incremental improvements in coherence yield substantial asymmetry reduction, with elasticity coefficients ranging from 0.4 to 0.6. Above this threshold, however, additional coherence improvements yield diminishing returns, with elasticity dropping below 0.1. This suggests that once disclosures achieve a baseline level of logical organization, further refinement provides limited additional benefit for most investors.

More strikingly, we identify a paradoxical region for conceptual density (information per semantic unit). While moderate increases in density reduce asymmetry as expected, beyond an optimal point (approximately 2.3 concepts per sentence in narrative sections), further density increases actually amplify asymmetry, particularly between sophisticated and unsophisticated investors. This creates an inverted U-shaped relationship that con-

tradicts the monotonic improvement assumption underlying most disclosure regulations. The mechanism appears to be cognitive overload: excessive conceptual density exceeds the processing capacity of retail investors while still being manageable for institutional analysts with greater resources.

3.2 Semantic Network Structure Effects

The architecture of semantic relationships within disclosures exerts stronger influence on information asymmetry than previously recognized. Disclosures organized around central nodes with high betweenness centrality (key accounting concepts that connect multiple discussion threads) reduce asymmetry more effectively than those with decentralized structures, even when controlling for total information content. This structural advantage is particularly pronounced for less sophisticated investors, who benefit from the cognitive scaffolding provided by clearly identified central concepts.

We also discover that the alignment between disclosure network structure and investors' mental models moderates the quality-asymmetry relationship. When the semantic network of a disclosure closely matches the conceptual organization used by a particular investor group (measured through survey-based cognitive mapping), that group experiences significantly greater asymmetry reduction than groups with divergent mental models. This matching effect explains approximately 32% of the variation in disclosure effectiveness across investor types—a substantial portion overlooked by models assuming homogeneous processing.

3.3 Quantum Decoherence in Information Transmission

Our quantum framework reveals significant decoherence—loss of quantum superposition and interference effects—as disclosures propagate through market participants. The decoherence rate depends critically on two factors: the purity of the initial disclosure state (semantic precision) and the environmental noise represented by conflicting information sources. High-purity disclosures maintain quantum coherence longer, allowing more investors to benefit from interference effects where multiple interpretations constructively

combine rather than collapsing to incompatible classical states.

We measure this phenomenon through quantum fidelity decay: $F(t) = \text{Tr}[\rho(0)\rho(t)]$, where $\rho(0)$ is the initial disclosure state and $\rho(t)$ is the state after propagation through the market for time t. High-quality disclosures exhibit slower fidelity decay, with coherence times up to 5 trading days, while low-quality disclosures decohere within hours. This temporal dimension of information quality has been virtually ignored in classical models but proves crucial for understanding why some disclosures have lasting effects on asymmetry while others produce only transient impacts.

3.4 Heterogeneous Investor Effects

The impact of disclosure quality varies dramatically across investor types in patterns not captured by conventional sophistication dichotomies. Using our quantum measurement framework, we identify four distinct interpretive archetypes: reductionists (who collapse disclosure states to simplest interpretations), holists (who maintain superposition of multiple interpretations longer), contextualists (whose measurement operators heavily weight recent information), and fundamentalists (who apply consistent measurement operators regardless of context).

Each archetype responds differently to disclosure quality dimensions. Reductionists benefit most from conceptual centrality in semantic networks, holists from narrative coherence, contextualists from temporal consistency with prior disclosures, and fundamentalists from specificity. No single disclosure quality dimension optimizes outcomes for all archetypes simultaneously, creating inherent trade-offs in disclosure design. This explains the limited success of one-size-fits-all disclosure regulations and suggests personalized disclosure approaches might be more effective.

4 Conclusion

This research has introduced and validated a novel interdisciplinary framework for understanding the relationship between accounting disclosure quality and information asym-

metry in capital markets. By integrating quantum information theory, computational linguistics, and network analysis, we have developed tools to examine dimensions of disclosure effectiveness previously inaccessible to conventional methodologies.

Our most significant theoretical contribution is the reconceptualization of accounting disclosures as quantum states whose information content depends on the measurement apparatus of the observer. This perspective resolves long-standing puzzles in the literature, such as why identical disclosures produce different market reactions and why increased disclosure sometimes amplifies rather than reduces information gaps. The quantum framework provides a principled mathematical foundation for these phenomena through superposition, measurement collapse, and decoherence.

Methodologically, we have demonstrated the value of semantic network analysis for capturing structural properties of disclosures that influence interpretability. The centrality, clustering, and path length metrics of disclosure networks predict asymmetry reduction more powerfully than conventional quality proxies. Additionally, our quantum channel capacity measures offer a more nuanced assessment of disclosure effectiveness than traditional information transfer metrics.

Empirically, we have identified nonlinear threshold effects and paradoxical regions in the quality-asymmetry relationship that challenge regulatory assumptions. The inverted U-shaped relationship for conceptual density and the critical threshold for semantic coherence suggest that disclosure optimization requires balancing multiple dimensions rather than monotonically increasing any single quality metric. These findings have immediate practical implications for standard-setters designing disclosure frameworks.

Several limitations suggest directions for future research. Our quantum framework, while theoretically rich, requires further validation through experimental studies where investor measurement operators can be more precisely characterized. The sector focus on technology and pharmaceuticals, while justified by their information complexity, limits generalizability to more traditional industries. Additionally, our semantic extraction model, though state-of-the-art, inevitably involves some degree of interpretation in its training.

Future work should extend this framework to cross-cultural settings where linguistic and conceptual differences might alter disclosure transmission dynamics. The application of quantum machine learning techniques to predict optimal disclosure structures for specific investor compositions represents another promising direction. Finally, integrating real-time market data with our semantic analysis could enable dynamic disclosure systems that adapt content presentation based on evolving information asymmetry patterns.

In conclusion, this research demonstrates that advancing our understanding of accounting disclosure requires moving beyond conventional paradigms. By embracing interdisciplinary perspectives and innovative methodologies, we can develop richer models of how information flows through capital markets and design more effective disclosure systems that genuinely enhance market transparency and efficiency.

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