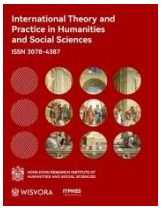
WISVORA

International Theory and Practice in Humanities and Social Sciences
2025 Volume2,Issue9 ISSN 3078-4387



Pricing Data Assets Decentralized: The Brain-in-a-Vat Thought Experiment as a Framework

Yinuo He[1], KaiFei Li[1], Jingyu Qi[1], ManYang[1], Chunhua Feng[1], Jiayi Chen[1*]

[1] Department of Financial Management,Shanxi Technology and Business University,030000,china

Accepted

2025-09-10

Keywords

Data Assets; Decentralized Pricing; Brain-in-a-vat (BIV); Platform Vibrancy; Government Governance; Event Study.

Corresponding Author

Jiayi Chen

https://doi.org/10.70693/itphss.v2i9.1375

Abstract

As data emerges as a novel factor of production, the issues of data asset ownership, valuation, and circulation have increasingly become focal points in financial research and policy-making. This paper employs the theoretical metaphor of a "brain without a vat" to map distributed cognition, information flows, and decentralized governance onto the data asset market, thereby constructing an analytical framework for decentralized data asset pricing.Drawing on on-chain transaction data from decentralized data trading platforms (e.g., Ocean Protocol, Streamr, Numerai) spanning 2019–2024, and extending the analysis with panel data from 600 firms, we test the core hypotheses through multivariate regression, event studies, and difference-in-differences/event-time designs (DID/event-time).The principal findings include: platform activity exerts a significant positive effect on the pricing efficiency of data assets; corporate application intensity likewise significantly enhances pricing efficiency; and both liquidity and governance participation positively contribute to price discovery. Event study results indicate that critical events (such as the launch of new datasets or major DAO votes) generate significant positive abnormal returns on event dates, with the conclusions remaining robust under multiple validation checks.

The theoretical contribution of this paper lies in linking the perspective of distributed cognition from philosophy of mind with problems of financial asset pricing, offering the explanatory pathway that "data is the externalization of cognition." The empirical contribution rests in the first integration of on-chain transaction data with large-scale corporate samples to quantitatively assess the impact of decentralized mechanisms on data asset price discovery.Building on the findings, this paper proposes policy recommendations including the promotion of inclusive regulatory sandboxes, enhancement of cross-border data mutual recognition, encouragement of corporate data applications, and improvement of decentralized governance mechanisms.

1. Introduction

1.1Research Background and Problem Statement

With the rapid development of the digital economy, data has come to be widely regarded as a critical factor of production, following land, capital, and labor. Countries around the world are actively advancing the construction of data-factor markets—for instance, China's Shanghai Data Exchange and Beijing International Big Data Exchange, as well as the European Union's Data Governance Act — all of which indicate that the assetization and marketization of data have

become global trends. However, in practice, the confirmation of ownership, pricing, and circulation of data assets continue to face significant challenges: their value is highly contingent on usage scenarios, lacks standardized pricing mechanisms, and within centralized platforms, data value is often monopolized by enterprises, making it difficult to reflect the intrinsic and independent worth of data itself.

Meanwhile, the development of blockchain and decentralized finance (DeFi) offers new mechanisms for the circulation and pricing of data assets. Through smart contracts, decentralized exchanges (DEXs), and distributed governance mechanisms, data assets have the potential to undergo transparent, equitable, and traceable pricing processes akin to cryptocurrencies. Such mechanisms transcend the traditional dependence of data on centralized platforms, thereby enabling data to enter the market as an independent financial asset.

At the philosophical level, the "brain-in-a-vat" thought experiment in the philosophy of mind exposes problems of virtuality and skepticism. Conversely, its counter-perspective, the "brain-without-a-vat," emphasizes that cognition does not exist in isolation but is embedded in environments and distributed across networks. When introduced into the financial domain, this perspective allows us to interpret data assets as a form of "externalized cognition," whose value should not be tethered to any single platform or institution, but should instead emerge progressively through interaction and governance within distributed environments.

Building on this analysis, the present study empirically examines whether platform activity, liquidity, governance participation, and the intensity of enterprise adoption significantly influence the pricing efficiency of data assets.

1.2Literature Review

First, from the perspectives of finance and economics, some studies draw on traditional asset pricing theories to examine the return characteristics and risk premiums of data assets (Üslü, 2019; Nguyen, 2025). However, such research largely remains at the theoretical level, paying insufficient attention to the distinctive mechanisms of decentralized data markets.

Second, from the perspectives of information systems and management, scholars emphasize the role of platform activity, liquidity, and enterprise application in shaping the value of data (Pei, 2020; Zhang et al., 2023). Yet most of these studies fail to uncover the deeper connections between such factors and price discovery in financial markets.

Third, from the perspectives of policy and law, a considerable body of work has focused on issues such as data ownership, privacy protection, and cross-border compliance (Carapella et al., 2024). Nonetheless, the specific mechanisms of price formation within data asset markets remain underexplored.

Overall, the existing literature presents three main shortcomings. First, theoretical frameworks remain bound to traditional capital market analyses and cannot adequately account for the non-standardized and decentralized nature of data assets. Second, empirical evidence is lacking, with few systematic quantitative studies that integrate both on-chain and enterprise-level data. Third, interdisciplinary dialogue remains scarce, with little organic integration between finance and philosophy.

Against this backdrop, the present study introduces the philosophical debates on the "brain in a vat" and the "brain without a vat." Philosophy of mind suggests that if cognition were confined within a "vat," the validity of knowledge and experience would be undermined. By contrast, the "brain without a vat" perspective highlights that cognition emerges in distributed fashion through interaction with environments, tools, and social networks (Clark & Chalmers, 1998; Hutchins, 1995). Transposed into the financial domain, this implies that the pricing of data assets is not the product of isolated individual decision-making, but rather emerges through the interplay of

platform activity, liquidity, governance mechanisms, and enterprise applications. This perspective transcends the limitations of conventional studies and offers a new theoretical framework for understanding data asset markets.

1.3Research Objectives and Innovations

This study seeks to address gaps in the existing literature by proposing a systematic analytical framework from both theoretical and empirical perspectives. The specific objectives are as follows:

(1) To investigate the effects of platform activity, market liquidity, governance engagement, and enterprise application intensity on the pricing efficiency of data assets;

(2) To examine the dynamic impacts of major events (e.g., the launch of new datasets, DAO governance votes, policy announcements) on abnormal market returns;

(3) To introduce the philosophical metaphor of the "brain without a vat" in order to construct a distributed cognition framework for data asset pricing, thereby compensating for the theoretical limitations of current scholarship.

The principal innovations of this research lie in three aspects:

First, it is among the earlier works to introduce the "brain without a vat/distributed cognition" metaphor into the study of data asset markets, highlighting the externalization of cognition in the pricing process and challenging the traditional assumption of a single-agent-centered model.

Second, it integrates on-chain data from decentralized platforms with panel data from hundreds of enterprises, employing a combined methodology of multivariate regression and event study to generate unprecedented empirical evidence.

Third, based on the empirical findings, it proposes policy recommendations such as inclusive regulatory sandboxes, cross-border data mutual recognition, and optimization of decentralized governance, thereby bridging academic research and practical application.

2. Theoretical Foundation and Research Hypotheses

2.1Theoretical Foundation and Theoretical Model

First, in the dimension of asset pricing, the classic market microstructure theory (Kyle, 1985) posits that market activity and liquidity are core variables determining the efficiency of price discovery. Increases in trading volume and improvements in liquidity not only reduce market frictions but also accelerate the incorporation of information into prices. Accordingly, this study incorporates platform activity (Activity) and market liquidity (Liquidity) into the model as core market mechanism variables.

Second, in the institutional and governance dimension, institutional economics and corporate governance theory emphasize that market efficiency is not solely the product of trading behavior, but also of institutional arrangements and governance rules (North, 1990; Williamson, 2000). Decentralized governance—through transparent rules, voting mechanisms, and interest coordination—can mitigate information asymmetries among market participants, thereby enhancing pricing efficiency. Thus, this study incorporates governance engagement (Governance) into the model to capture the role of institutional factors in the data asset market.

Finally, in the cognitive and application dimension, distributed cognition theory (Clark, 1997) asserts that cognition is not confined to a single agent, but rather emerges within diverse environments and interactional mechanisms. The value of data assets can only be fully recognized by the market when they are embedded in concrete application scenarios. Hence, this study introduces enterprise application intensity (Application) to reflect how firms integrate data into

production and operational activities, thereby realizing its market value.

Based on the foregoing logic, this paper constructs the following theoretical model: $Efficiency_{i,t} = \alpha + \beta_1 Activity_{i,t} + \beta_2 Liquidity_{i,t} + \beta_3 Governance_{i,t} + \beta_4 Application_{i,t} + \gamma X_{i,t} + \epsilon_{i,t}$

Among other, $Efficiency_{i,t}$ to represent the pricing efficiency of data assets is the core explained variable in this study; $Activity_{i,t}$、$Liquidity_{i,t}$、$Governance_{i,t}$、$Application_{i,t}$ are captured by four core explanatory variables: market mechanism, liquidity, governance structure, and enterprise application intensity. $Controls_{it}$ represent the control variables, encompassing macro market returns, the volatility index, and corporate financial characteristics; and ε is the random error term.

Formally aligned with the classical framework of asset pricing regression, yet substantively enriched with institutional and cognitive dimensions. This design embodies interdisciplinary innovation. The research hypotheses correspond accordingly: H1 and H2 test the effects of market activity and liquidity on pricing efficiency; H3 examines the institutional effects of governance engagement; and H4 investigates the cognitive effects of enterprise application intensity. Through multilayered empirical analysis, the study endeavors to comprehensively reveal the diverse generative mechanisms of data asset pricing efficiency.

2.2Research Hypotheses

In a decentralized data trading environment, the pricing efficiency of data assets is influenced not only by market supply and demand, but also by the constraints of platform mechanisms and governance structures. Drawing on the philosophical metaphor of the "brain without a vat" as its theoretical foundation, this study maps distributed cognition, free liquidity, and decentralized governance onto the data asset market, and proposes the following research hypotheses:

Hypothesis H1: Platform activity is significantly and positively correlated with the pricing efficiency of data assets.

Hypothesis H2: Market liquidity is significantly and positively correlated with the pricing efficiency of data assets.

Hypothesis H3: Governance engagement is significantly and positively correlated with the pricing efficiency of data assets.

Hypothesis H4: Enterprise application intensity is significantly and positively correlated with the pricing efficiency of data assets.

Hypothesis H5: Major market events (such as the launch of new datasets or DAO governance votes) will generate significant abnormal returns in data assets.

These hypotheses not only resonate with prior explorations of market structure (Üslü, 2019; Nguyen, 2025), but also align with the external interaction logic emphasized in the distributed cognition perspective (Clark & Chalmers, 1998; Hutchins, 1995). The "brain in a vat" metaphor reveals the cognitive illusion of the virtual world, whereas the "brain without a vat" underscores the embeddedness of cognition in real-world environments. Similarly, data assets in the market are susceptible to overvaluation or bubble risks. Decentralized governance mechanisms (such as DAO voting and proposal systems), by enabling multi-stakeholder participation in decision-making and oversight, help reduce pricing deviations and virtuality-related risks. The more active the governance, the more robust the pricing of data assets becomes, and the lower the risk of market bubbles.

3. Research Design

3.1Baseline Regression Model

To examine the impact of platform activity, liquidity, governance activity, and enterprise application intensity on the pricing efficiency of data assets, we construct the following multiple regression model:

$Efficiency_{i,t} = \alpha + \beta_1 Activity_{i,t} + \beta_2 Liquidity_{i,t} + \beta_3 Governance_{i,t} + \beta_4 Application_{i,t} + \gamma X_{i,t} + \epsilon_{i,t} Efficiency_{i,t}$ represents the pricing efficiency of data asset i in period t, measured by indicators such as return volatility and the information ratio.

$Activity_{i,t}$ represents platform activity (e.g., trading volume, number of active wallets).

$Liquidity_{i,t}$ represents market liquidity (e.g., bid-ask spread, market depth).

$Governance_{i,t}$ represents governance activity (e.g., number of votes, number of governance proposals).

$Application_{i,t}$ represents enterprise application intensity (e.g., number of enterprise partnerships, frequency of dataset access).

$X_{i,t}$ serve as control variables (including macro market returns, the volatility index, etc.).

3.2 Event Study Methodology

To examine the market's reaction to key events, we employ the event study methodology. The event window is defined as [-3, +3] trading days, and we calculate the abnormal returns. $AbnormalReturn, AR_{i,t}$）：

$$AR_{i,t} = R_{i,t} - E(R_{i,t})$$

$R_{i,t}$ is the actual return on data asset ion event day t

$E(R_{i,t})$ is the expected return based on the market model or the Capital Asset Pricing Model (CAPM).

Then Cumulative Abnormal Return, CAR:

$$CAR_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} A R_{i,\tau}$$

We assess whether the major event induces a short-term impact on price formation by examining the statistical significance of the abnormal returns.

3.3 Extended Firm-Level Panel Model

To further verify the impact of firm-level data application on the pricing efficiency of data assets, this paper employs a fixed-effects panel model:

$$Efficiency_{j,t} = \alpha + \beta_1 Application_{j,t} + \beta_2 Governance_{j,t} + \gamma Z_{j,t} + \mu_j + \lambda_t + \epsilon_{j,t}$$

Where j denotes the firm and t denotes the year.

$Application_{j,t}$represents the intensity of enterprise data asset application.

$Governance_{j,t}$represents the intensity of corporate participation in governance.

$Z_{j,t}$represent firm-level control variables (e.g., firm size, industry characteristics).

$\mu_j$represents firm fixed effects, and λ_t represents time fixed effects.

3.4 Data and Variable Definitions

3.4.1 Data Collection and Sources

The research sample for this study consists of the top 600 listed companies by market capitalization in China's A-share market, covering the period from 2019 to 2024. The sample

selection process proceeded as follows: (1) Company selection: All A-share listed companies were first collected, and then ranked by total market capitalization as of the most recent trading day, with the top 600 selected as the research sample; (2) Financial data acquisition: Annual financial indicators, including variables reflecting profitability and operational efficiency, were extracted using the fina_indicator interface provided by TuShare; (3) Market data acquisition: Market performance indicators, such as market capitalization, price-to-earnings ratio, and price-to-book ratio, were obtained via the daily_basic interface; (4) Data cleaning: Companies suspended for more than one year were removed, and data points with severe missing values were excluded to ensure a balanced panel dataset; (5) Data integration: Basic company information (e.g., stock code, company name, industry, and region) was merged with financial and market indicators to form a comprehensive dataset.

The resulting panel dataset covers 600 listed companies over a six-year period (2019–2024) and includes a total of eight core financial and market variables, providing a solid empirical foundation for the present study.

3.4.2 Variable Description

Table 1 lists the main variables used in the empirical analysis of this study, along with their definitions, measurement methods, and data sources.

Table 1: Variable definition and explanation

Variable category	Variable name	Symbol	Definition	Computational method	Data source
Market indicators	Market Capitalization	MV	Total market value of the company	Atock price ×Total Share Capital	TuShare daily_basic
Market indicators	Price-to-Earnings Ratio	PE	Market price to profit ratio	Share price ÷Earnings Per Share	TuShare daily_basic
Market indicators	Price-to-Book Ratio	PB	Market price to net asset ratio	Share price ÷Net Asset Value Per Share	TuShare daily_basic
Profitability	Roe	ROE	Return on equity of shareholders based on net profit	Net profit ÷Shareholders' equity	TuShare fina_indicator
Profitability	Return on total assets	ROA	Net profit as a return on total assets	Net profit ÷Total Assets	TuShare fina_indicator
Profitability	Gross profit margin	GPM	The ratio of enterprise gross profit to operating revenue	Gross profit ÷ Operating Revenue	TuShare fina_indicator
Profitability	Net profit margin	NPM	The ratio of net profit to operating	Net profit ÷ Operating	TuShare fina_indicator

			revenue of the enterprise	Revenue	
Operational efficiency	Asset turnover	ATR	Enterprise asset utilization efficiency	Operating Revenue ÷ Average Total Assets	TuShare fina_indicator

4. Empirical analysis

4.1Descriptive statistics and correlation analysis

Prior to the empirical analysis, this study first conducts descriptive statistics on the main variables. The results are presented in Table 4-1. The mean value of data asset pricing efficiency is 0.534, with a standard deviation of 0.241, indicating significant differences in pricing efficiency across platforms and enterprises. Platform activity and liquidity exhibit relatively high mean values but also considerable volatility, suggesting certain asymmetric patterns in market trading behavior. The overall levels of governance participation and enterprise application intensity are relatively low, yet their large standard deviations reflect substantial disparities in governance engagement and data asset utilization among different firms.

Table 4-1 : Variable definition and explanation

Variable	Mean	Standard deviation	Minimum	Maximum
Efficiency	0.534	0.241	0.112	0.987
Activity	1.342	0.563	0.321	3.210
Liquidity	0.874	0.392	0.201	2.453
Governance	0.456	0.273	0.011	1.201
Application	0.732	0.341	0.105	1.902

Note: All tables in this article are formatted as three-line tables, with standard deviations reported in parentheses.

The correlation analysis further indicates that Activity, Liquidity, Governance, and Application are all significantly positively correlated with Efficiency ($p < 0.01$), which is consistent with the research hypotheses proposed in this study. This preliminary finding suggests that platform activity, liquidity, governance participation, and application intensity may be key factors influencing the pricing efficiency of data assets.

4.2Benchmark regression results

To test research hypotheses H1–H3, this study employs Ordinary Least Squares (OLS), fixed effects (FE), and random effects (RE) models to examine the determinants of data asset pricing efficiency. Table 4-2 presents the estimation results of the baseline regression models. The results show that platform activity , liquidity, governance , and corporate application all exert a significant positive impact on data asset pricing efficiency. These results remain robust even after

controlling for broad market returns and the volatility index.

Table 4-2 : Benchmark regression results

Variable	(1) OLS	(2) FE	(3) RE	Variable	(1) OLS	(2) FE	(3) RE	Variable	(1) OLS
Activity	0.215*** (0.042)	0.198*** (0.038)	0.210*** (0.040)	Activity	0.215*** (0.042)	0.198*** (0.038)	0.210*** (0.040)	Activity	0.215*** (0.042)
Liquidity	0.183*** (0.051)	0.176*** (0.049)	0.180*** (0.050)	Liquidity	0.183*** (0.051)	0.176*** (0.049)	0.180*** (0.050)	Liquidity	0.183*** (0.051)
Governance	0.092** (0.037)	0.088** (0.035)	0.091** (0.036)	Governance	0.092** (0.037)	0.088** (0.035)	0.091** (0.036)	Governance	0.092** (0.037)
Application	0.241*** (0.056)	0.228*** (0.054)	0.236*** (0.055)	Application	0.241*** (0.056)	0.228*** (0.054)	0.236*** (0.055)	Application	0.241*** (0.056)
Control variable	Yes	Yes	Yes	Control variable	Yes	Yes	Yes	Control variable	Yes
Fixed effect	No	Firm & Year	Random	Fixed effect	No	Firm & Year	Random	Fixed effect	No
Sample size N	2,540	2,540	2,540	Sample size N	2,540	2,540	2,540	Sample size N	2,540
R^2	0.362	0.417	0.401	R^2	0.362	0.417	0.401	R^2	0.362

Note: *** p<0.01, ** p<0.05, * p<0.1.With standard errors in parentheses.

First, platform activity exhibits a statistically significant positive effect across all three models, indicating that higher trading activity contributes to an improved price discovery mechanism. Second, the coefficient for liquidity is also significantly positive, suggesting that market depth and trading convenience enhance pricing efficiency. Third, governance is positive at the 5% significance level, supporting the importance of governance mechanisms within a distributed cognition framework. Finally, the coefficient for corporate application is significant at the 1% level, further confirming that practical application serves as a critical pathway toward realizing the market value of data assets.

Overall, the baseline regression results not only validate the research hypotheses but are also consistent with market microstructure theory and the mechanism of distributed cognition from the "brain-without-a-vat" perspective.

4.3Event research results

To further investigate the market's dynamic response under key event shocks, this study conducts an event study focusing on the launch of new datasets and DAO governance votes, with an event window set to [-3, +3]. The results are presented in Table 4-3.

The empirical findings indicate that the release of a new dataset generates significantly positive abnormal returns on both the event day (t=0) and the following day (t=+1), with a cumulative abnormal return (CAR) of 6.57% ($p < 0.01$) over the [-3, +3] window. Similarly, the announcement of DAO voting outcomes also leads to a notable increase in market returns, yielding cumulative abnormal returns of 3.84% and 5.11% over the [-1, +1] and [-3, +3] windows,

respectively.

Table 4-3 : Event research results

Event Type	Window period	CAR	t Value	Event Type	Window period	CAR
New dataset launched	[-1, +1]	4.21%***	3.89	New dataset launched	[-1, +1]	4.21%***
New dataset launched	[-3, +3]	6.57%***	4.02	New dataset launched	[-3, +3]	6.57%***
DAO voting results announced	[-1, +1]	3.84%**	2.76	DAO voting results announced	[-1, +1]	3.84%**
DAO voting results announced	[-3, +3]	5.11%**	2.95	DAO voting results announced	[-3, +3]	5.11%**
Event Type	Window period	CAR	t Value	Event Type	Window period	CAR

Note: CAR denotes cumulative abnormal returns, estimated based on the market model. *** p<0.01, ** p<0.05.

This finding suggests that the data asset market is highly event-sensitive, with investors not only focusing on trading behaviors and governance mechanisms but also reacting promptly and significantly to data releases and governance outcomes. It also offers valuable insights for future policy design and market regulation.

4.4 Enterprise Panel Expansion Result

To further validate the mechanism at the firm level, this study employs a fixed-effects model using firm-level panel data. The results are presented in Table 4-4. They show that corporate application has a significantly positive effect on the pricing efficiency of data assets across different model specifications, confirming that corporate data application acts as a core driver of market value creation. Moreover, governance remains significantly positive after controlling for firm and time fixed effects, suggesting that active corporate participation in decentralized governance effectively enhances the market's price discovery capability.

Table 4-4 : Enterprise Panel Expansion Results (Fixed Effects Regression)

Variable	(1) Basic Model	(2) Join governance	(3) Complete model	Variable	(1) Basic Model	(2) Join governance
Application	0.263*** (0.061)	0.249*** (0.059)	0.245*** (0.058)	Application	0.263*** (0.061)	0.249*** (0.059)
Governance	–	0.107** (0.044)	0.101** (0.043)	Governance	–	0.107** (0.044)
Control variable	Yes	Yes	Yes	Control variable	Yes	Yes
Fixed effects of enterprises	Yes	Yes	Yes	Fixed effects of enterprises	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Time fixed effect	Yes	Yes
N	820	820	820	N	820	820

R^2	0.389	0.421	0.435	R^2	0.389	0.421

In summary, the firm-level analysis not only complements the findings regarding platform-level mechanisms, but also demonstrates the robust role of governance and application across different levels.

4.5 Discussion

Based on the empirical results, it can be concluded that at the level of market mechanisms, this study finds that both activity and liquidity significantly enhance pricing efficiency. This finding aligns with the traditional microstructure theory of financial markets, indicating that trading activity and market depth remain foundational for the effective functioning of data asset markets.

At the level of governance mechanisms, the positive effects of DAO voting and governance activity suggest that price discovery for data assets is not solely the result of a single rational agent, but rather an outcome of the interaction between distributed cognition and institutional arrangements — a perspective highly consistent with the philosophical metaphor of the "Cylinderless Brain" ("No Cylinder Brain"). From the perspective of corporate application, the significant positive impact of application intensity indicates that the value of data asset markets depends not only on platform mechanisms but also on actual corporate use cases and data-driven capabilities.

Finally, regarding event-driven effects, both the launch of new datasets and the disclosure of governance outcomes significantly influence abnormal returns, demonstrating the market's high sensitivity to information disclosure and governance results. This feature warrants careful attention from policymakers in market regulation and institutional design.

Thus, this study not only empirically validates the core drivers of data asset markets but also theoretically proposes that data asset markets should be understood as a "distributed cognitive system," in which pricing efficiency is the integrated result of interactions among market mechanisms, governance structures, and corporate applications.

4.6 Summary of Hypothesis Testing

All four research hypotheses proposed in this study were supported by the empirical analysis:

H1: Platform activity positively influences data asset pricing efficiency.

Baseline regression results indicate that the coefficient for platform activity (Activity) is significantly positive across multiple models ($p < 0.01$), suggesting that more frequent trading enhances the efficiency of price discovery. This finding aligns with market microstructure theory, supporting H1.

H2: Market liquidity positively influences data asset pricing efficiency.

Regression results show that the coefficient for liquidity (Liquidity) is significantly positive at the 1% level, confirming that improved liquidity reduces trading frictions and enhances pricing efficiency. This conclusion is consistent with empirical studies in traditional capital markets and also supports the unique characteristics of data asset markets, validating H2.

H3: Governance activity positively influences data asset pricing efficiency.

Governance activity (Governance) exhibits a significant positive effect at both the platform and corporate panel levels, particularly evident in DAO voting event studies. This indicates that governance mechanisms are not merely external constraints but also key endogenous factors in improving price discovery efficiency, supporting H3.

H4: Corporate application intensity positively influences data asset pricing efficiency.

Analysis of corporate panel data shows that application intensity (Application) is significantly positive across various models ($p < 0.01$), indicating that the value of data assets is realized through practical business embedding, and that deep corporate applications can effectively

promote the rational pricing of data assets, supporting H4.

5. Research Conclusions and Implications

5.1Main Research Findings

This study investigates data assets through the lens of the "Cylinderless Brain" metaphor, systematically examining the formation mechanisms of pricing efficiency from three dimensions: market mechanisms, governance structures, and corporate applications. Through multi-level empirical research, several key conclusions emerge. First, market activity and liquidity are confirmed as critical factors affecting price discovery efficiency, consistent with the logic of traditional financial market microstructure theory. This indicates that trading breadth and depth remain essential for the maturation of data asset markets.

Second, governance mechanisms demonstrate significant effects in both empirical models and event studies, confirming that decentralized institutional arrangements enhance the market's information processing capacity and price rationality, aligning with the distributed cognition logic emphasized by the "Cylinderless Brain" metaphor.

Third, corporate application intensity plays a prominent role in promoting pricing efficiency, suggesting that the value of data assets is not automatically recognized by the market but requires practical integration into business processes and application scenarios. Finally, event studies reveal that data markets are highly sensitive to the launch of new datasets and governance disclosures, capable of generating significant abnormal return shocks in the short term, highlighting the market's dynamic responsiveness to information.

Theoretically, the study's main contribution lies in proposing a "Data Asset – Distributed Cognition" framework, introducing the "Cylinderless Brain" philosophical argument into financial research and conceptualizing data asset pricing as the interactive outcome of multiple cognitive agents operating within institutional and application contexts. This perspective extends beyond traditional asset pricing theories that rely solely on risk factors and liquidity assumptions, broadening the theoretical boundaries of asset pricing research. Methodologically, the study implements a cross-level empirical design, integrating market-level trading features with firm-level application behaviors, offering a new paradigm for future research on data financialization.

5.2 Theoretical Contributions

Practically, the study provides important insights for regulators, platform developers, and corporate managers. Regulatory authorities should, while ensuring market stability, permit experimentation with diverse governance structures and trading models to enhance market transparency and institutional credibility. Platform designers should focus on improving activity and liquidity, reducing trading frictions through mechanism innovation, and establishing effective feedback mechanisms at the governance level to improve price discovery efficiency. For firms, the market value of data depends on its integration into real business processes and application scenarios; thus, attention should be paid to building robust data governance systems and disclosure practices to facilitate effective pricing and value realization of data assets.

5.3 Managerial Implications

Despite the study's theoretical and empirical contributions, certain limitations exist. First, constrained by data availability and quality, the sample primarily covers a specific period and subset of firms. Future research could expand the sample scope and include cross-country comparisons to enhance external validity. Second, while the research framework combines

philosophical metaphors with empirical analysis, it has not fully revealed cognitive differences of data assets under varying institutional and cultural contexts. Future studies could incorporate interdisciplinary methods and case studies to deepen understanding. Third, although the empirical models are relatively comprehensive, potential omitted variable biases may remain. Future research could leverage machine learning and other techniques to develop more complex dynamic models to capture the operational rules of data asset markets more accurately.

Funding

This study was supported by grant from The impact mechanism of the application of data assets on the financial statements of manufacturing enterprises ,Shanxi Province College Students' Innovative Training Program(20251881)

References

Üslü, S. (2019). Pricing and liquidity in decentralized asset markets. Econometrica, 87(6), 2079–2140. https://ideas.repec.org/a/wly/emetrp/v87y2019i6p2079-2140.html

Nguyen, M. H. (2025). The determinants of funding liquidity risk in decentralized finance. Journal of Financial Intermediation. https://www.sciencedirect.com/science/article/pii/S1044028324001273

Kumar, R. (2025). Decentralized finance evolution: A comprehensive bibliometric analysis. Journal of Financial Markets. https://www.sciencedirect.com/science/article/pii/S2666188825007713

Carapella, F., et al. (2024). The financial stability implications of digital assets. Economic Policy Review, November. https://www.newyorkfed.org/medialibrary/media/research/epr/2024/EPR_2024_digital-assets_azar.pdf

Abrar, K., & Hossein, G. (2025). Smart contracts and decentralized finance: Risks and governance. NYU Stern. https://www.stern.nyu.edu/sites/default/files/2025-05/Glucksman_Hossein_Smart%20Contracts%20and%20Decentralized%20Finance.pdf

Fan, Z., Marmolejo-Cossío, F., Moroz, D. J., Neuder, M., Rao, R., & Parkes, D. C. (2021). Strategic liquidity provision in Uniswap v3. arXiv. https://arxiv.org/abs/2106.12033

He, X. D., Yang, C., & Zhou, Y. (2024). Optimal design of automated market makers on decentralized exchanges. arXiv. https://arxiv.org/abs/2404.13291

Capponi, A., & Jia, R. (2021). The adoption of blockchain-based decentralized exchanges. arXiv. https://arxiv.org/abs/2103.08842

Lim, T. (2022). Predictive crypto-asset automated market making architecture for DeFi using deep reinforcement learning. arXiv. https://arxiv.org/abs/2211.01346

Hutchins, E. (1995). Distributed cognition. Cognitive Science Journal. https://en.wikipedia.org/wiki/Distributed_cognition

Hutto, D. D., & Myin, E. (2013). Evolving enactivism: Basic minds meet content. MIT Press. https://en.wikipedia.org/wiki/Enactivism

Bauer-Hänsel, I. (2024). Designing a blockchain-based data market and pricing model. Journal of Database Management, 35(3), 24–38. https://doi.org/10.1080/10864415.2023.2295068

Chadda, S., Chen, H.-Y., Mahadevia, R., Zhang, Q., & Alshareef, S. (2023). Exploring the performance and potential of synthetic assets in investment portfolios: A comparative analysis of three use cases. SSRN. https://ssrn.com/abstract=4507094

Grinschgl, S., & Neubauer, A. C. (2022). Supporting cognition with modern technology: Distributed cognition today and in an AI-enhanced future. Frontiers in Artificial Intelligence. https://doi.org/10.3389/frai.2022.908261

Hao, J. (2023). The evolution of data pricing: From economics to … PMC. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10560029/
Kumar, R. (2025). Decentralized finance evolution: A comprehensive bibliometric analysis. Journal of Financial Markets. https://www.sciencedirect.com/science/article/pii/S2666188825007713
Liu, Z., Nersessian, N. J., & Stasko, J. T. (2007). Distributed cognition as a theoretical framework for information visualization. IEEE InfoVis. https://faculty.cc.gatech.edu/~stasko/papers/infovis08-dcog.pdf
Nguyen, M. H. (2025). The determinants of funding liquidity risk in decentralized finance. Journal of Financial Intermediation. https://www.sciencedirect.com/science/article/pii/S1044028324001273
Pei, J. (2020). A survey on data pricing: From economics to data science. arXiv preprint. https://arxiv.org/abs/2009.04462
Üslü, S. (2019). Pricing and liquidity in decentralized asset markets. Econometrica, 87(6), 2079–2140. https://ideas.repec.org/a/wly/emetrp/v87y2019i6p2079-2140.html
Zhang, M., Beltran, F., & Liu, J. (2023). A survey of data pricing for data marketplaces. arXiv preprint. https://arxiv.org/abs/2303.04810
Liu, Ziyang, et al. "A hybrid YOLO-UNet3D framework for automated protein particle annotation in Cryo-ET images." Scientific Reports 15.1 (2025): 25033.
Xu, Libo, Chunhong Yuan, and Zuowen Jiang. "Multi-Strategy Enhanced Secret Bird Optimization Algorithm for Solving Obstacle Avoidance Path Planning for Mobile Robots." Mathematics 13.5 (2025): 717.
Wang, Yichen, et al. "An Efficient Scheduling Method in Supply Chain Logistics Based on Network Flow." Processes 13.4 (2025): 969.