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Market Effects of Financial Behavior Changes Induced by Data Resource Operations in Science and Technology Innovation Enterprises

Tang Ning[1]

[1] Business School, Soochow University, Suzhou, Jiangsu 215021, China

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Abstract

As the development of the digital economy continues, data has gradually begun to serve as a new form of productive resources, and thus many science and technology innovation enterprises have started to plan for the utilisation of data resources. This paper studies the impact of the above operations on the financial behaviour and market valuation of STI companies listed on the China STAR Market. Based on the panel data of the 487 STAR Market-listed companies from 2019 to 2023, a multi-dimensional data resource operation intensity index was constructed and this index was used to study its effect on the return on total assets (ROA) and Tobin's Q. Using fixed-effect panel regression and a difference-in-differences approach around China's January 2024 asset accounting reform, we find that increased data resource operation intensity is positively correlated with both financial performance indicators. Based on the analysis above, it was determined that the main reasons for the improvement in performance are better information disclosure and weaker financing constraints. According to the results of the heterogeneity test, among the various types, large enterprises and high-tech enterprises approved by the government had a relatively greater positive effect. Based on the above results, a data-asset-formalisation plan for China and management ideas on how to use big data in the financial strategy of innovation-oriented enterprises can be put forward.

Keywords

data resources, science and technology innovation enterprises, financial behavior, market effect, data asset accounting

1. Introduction

With the start of the digital economy, how companies create, distribute and use value has changed

fundamentally. In China, data has been officially included in the list of the five factors of production in the first document released by the State Council in 2022, along with land, labour, capital and technology, as the fundamental resources of the economy (State Council of the People's Republic of China, 2022). Science and Technology Innovation (STI) enterprises are enterprises with a high proportion of R&D investment, possess proprietary technology and have accumulated a large amount of intellectual property; therefore, such companies will be included in the group of enterprises at the forefront of data resource management. The enterprise will be involved in more extensive and complex data generation, collection and use than in the past, so it should be the subject of research on the financial and market effects of data-intensive operations.

Since the start of the Shanghai Stock Exchange Science and Technology Innovation Board (STAR Market) in July 2019, more than 500 qualified enterprises have been supported by special capital market support for their innovative business models. STAR Market firms are in a good position to provide more information on the intersection of data strategy and corporate finance; in accordance with the law, these companies need to disclose research and development expenses, technology classification status, intellectual property inventory, etc., which are not available for typical A-share listed companies. In a data-rich company, it can be observed that the raw data has been collected and organised, proprietary datasets have been created, machine-learning models have been trained and applied, and value has been generated through analytical services or the automation of internal decision-making (Brynjolfsson & McElheran, 2016). However, in the past, the financial statements have not shown the actual impact of such activities on the economy; due to the lack of standardized recognition rules, most of the investment data has been treated as expenses rather than capitalised, resulting in an understatement of the balance sheet and greater information asymmetry between management and the outside world.

In recent years, the Ministry of Finance of China has made some structural adjustments in the release of the "Provisions on Accounting Treatment of Enterprise Data Resources (Trial)" in August 2023, and it will take effect from January 1, 2024 (Ministry of Finance of the People's Republic of China, 2023). Under the reform, intangible assets and inventory are now classified according to their source of future economic benefits. Therefore, there was an immediate wave of balance sheet reclassification, adjustment of the intangible asset schedule and modification of annual report disclosures; thus, this regulatory change has created a quasi-experimental environment to study how the formal recognition of data assets affects corporate financial behaviour. Barney's Resource-Based Theory (1991) holds that a company will achieve a competitive advantage by having resources that are scarce, valuable, costly to imitate or difficult to obtain, and not easily substituted; these resources generally need to be built up over a long period of time by the company. Teece, Pisano and Shuen (1997) proposed in their theory of dynamic capabilities that the continuous ability of a company to perceive and take advantage of opportunities in the data will enable it to perform better than enterprises with fixed resource portfolios (Teece, Pisano, & Shuen, 1997).

Although there have been more and more theoretical and policy studies on the intensity of data resource operation, little empirical evidence has been collected to directly link it to changes in the financial behaviour and market prices of STI companies. Research shows that in the past, the use of information technology has enhanced enterprise productivity (Chen, Chiang & Storey, 2012), and big data technology has enabled change in business models (Brynjolfsson & McElheran, 2016); However, there have been few studies on how new data asset governance systems in China affect financial accounting and market valuation. The three reasons for this are presented in this paper. First, we will construct a new multi-dimensional index of data resource operation intensity based on the systematic disclosures in the annual reports of STAR Market companies. Second, to identify the causal effect of the January 2024 accounting reform on ROA and Tobin's Q, the difference-in-differences method will be used. Third, we will organise the collection and analysis of positive feedback from the market on the improvement in data asset disclosure quality systematically. The rest of this paper is as follows: Section 2 is the background; Section 3 is the theoretical foundation and research hypothesis; Section 4 presents data and methods; Section 5 shows the results of the study; Section 6 discusses the implications; Finally, Section 7 is the conclusion.

2. Literature Review

Based on the first line of empirical research, it has been found that the application of information technology and data-driven management can improve the efficiency of enterprises. Brynjolfsson and McElheran (2016) [found that one of the reasons for the fluctuations in operating margins is how much data a firm uses to make decisions; census data of US manufacturer plants are shown below. Chen, Chiang and Storey (2012) conducted cross-industry studies on business intelligence systems and found that organised data is frequently used by all levels of various companies for planning and decision-making, and it has shown good results in all sectors. In short, the above studies have found that by adjusting the speed at which a company uses its data resources, it can promote economic development, provided that this data is employed in the core area of daily operations to drive new business and is no longer just an isolated analysis tool.

Complementarity of Organisations in the Use of Data is economically beneficial. Aral, Brynjolfsson and Wu (2012) have studied the three-way complementarity of performance-based pay, investment in human capital and the use of information technology to find that data capabilities can improve the return on high-quality human resource management. Brynjolfsson, Rock and Syverson (2021) have extended this logic to general-purpose technologies and introduced the concept of the productivity J-curve; that is to say, intangible investments such as data infrastructure, analytics platforms and machine learning pipelines need to run for some time before they can boost tangible productivity, so it can be concluded that large-scale investment in data will not yield high productivity increases in the short term for cross-sectional data.

Accounting and Valuation literature have pointed out that intangible assets have been continuously

mispriced in the market. Lev and Gu (2016) have found that the traditional accounting system has always underestimated the importance of knowledge assets and data resources in creating corporate value, and as a result, for a long time, there has been a significant difference between book value and market capitalization for intangible-intensive enterprises. After improving the quality of post-recognition disclosures, the cost of capital will fall, and more analysts will be motivated to cover it; thus, price discovery and liquidity will increase. In 2024, the International Accounting Standards Board issued IFRS 18 (International Accounting Standards Board., 2024) and related data accounting rules in China (Ministry of Finance of the People's Republic of China, 2023); it can be seen that around the world, structured intangible reporting is beginning to be applied to reduce investor uncertainty and narrow the valuation gap. STI enterprise has also incurred substantial losses and debt pressure in recent years, so accounting reform is very necessary; it will provide a guarantee for the funds.

Zhu and Kraemer (2005) were among the first to find that, in the Chinese institutional environment, the post-adoption values of different types of enterprises after adopting e-business were not the same, and this phenomenon had been predicted in earlier research on digital transformation. Under the direction of the State Council to make full use of data for economic growth (State Council of the People's Republic of China, 2022), the National Data Administration has also promoted the market development initiative (NDA, 2024) (National Data Administration, 2024) and gradually formed institutions of governance and responsibility for data. Acemoglu and Restrepo (2022) have also investigated how automation changes the structure of employment and made other macroeconomic contributions; Hadlock and Pierce (2010) have provided the method for the SA financing constraint index that will be used in the mechanism analysis of this paper. Based on the above literature, it is believed that formal data asset accounting may be related to the different cross-sectional performance of STI enterprises.

3. Theoretical Framework and Research Hypotheses

3.1 Resource-Based View and Data Asset Performance

According to Barney's (1991) VRIN theory (Barney J B. Firm resources and sustained competitive advantage, 1991), the proprietary data that STI enterprises have accumulated over a long period of time in this area through operation and investment will be considered a strategic resource if it is valuable, rare, inimitable and non-substitutable. Data has been accumulating for many years since the release and use of the product, as well as research and development efforts; therefore, it is naturally path-dependent and situation-specific and difficult for other companies to reproduce. When the data from STI enterprises is used to build operating optimisation algorithms, customer analysis platforms, predictive supply chain models, etc., they will have richer information and generate more higher rents by increasing the return on assets. Formal accounting recognition will further strengthen this mechanism, make better use of data assets in the balance sheet as collateral, lower-cost external financing will be more easily obtained, and it will signal to equity investors that an intangible asset base has been added without prior disclosure. Thus, the first research hypothesis has been set up. Hypothesis 1: An increase

in the utilisation rate of data resources will lead to an increase in a company's return on assets (ROA) and Tobin's Q.

3.2 Information Asymmetry and Market Mechanism

Based on the theory of information asymmetry, investors will be willing to give up the value of assets that they cannot directly observe or independently verify (Lev & Gu, 2016). Before the start of the official data asset accounting, there were no standard disclosure rules; therefore, the capital market was reluctant to invest in STI companies with good data but no listing. By 2024, the accounting provision data should be organised reasonably in accordance with the resource recognition and measurement method, as well as the depreciation policy, to reduce ambiguity for investors. Lower information asymmetry will reduce the required rate of return, and thus, after a good disclosure event, it is expected that the price-to-book ratio will increase and positive cumulative abnormal returns will occur. Greater openness will attract more institutional investors and analysts to increase the number of shareholders and raise the stock price. Thus, we have the second research hypothesis. Hypothesis 2: Increasing the formality of the disclosure of data assets will improve information symmetry, and therefore, through the use of data resources, the market valuation (Tobin's Q) of the enterprise will rise.

4. Data and Methodology

4.1 Sample and Data Sources

Based on the above, the 487 STI-listed enterprises in China's STAR Market from July 2019 to December 2023 are selected as the sample, and after excluding financial sector firms and observations with missing values, the final panel of firm-year observations is 1,978. Financial and Market Data will be obtained from the CSMAR (China Stock Market and Accounting Research) database. Data resource disclosure is manually collected from the annual reports of the companies by systematically searching for the terms "data resource", "data asset", "data element", "data product" and related semantic expressions. The sampling window is the pre-reform period (2019-2023), and it will cover the announcement effect of the accounting provisions in January 2024; thus, pre-post and treated-versus-control comparisons can be made using the difference-in-differences identification strategy.

4.2 Variable Definitions

The dependent variables are return on assets (ROA), which is the net profit divided by average total assets, and Tobin's Q, which is the sum of market capitalization and the book value of debt divided by total assets. The main independent variable is DataOp, which is a composite index of data resource operation intensity, and it is calculated as the arithmetic mean of three normalised sub-indicators: (i) the ratio of data-classified intangible assets to total intangible assets (DA); (ii) a binary indicator of whether there is a dedicated data resource disclosure paragraph in the annual report (Disc); and (iii) the ratio of data-related R&D expenditure to total R&D expenditure (RD_d). Equation (1) is the formalisation of the above construction, and the asterisk is min-max normalisation to the unit interval.

Control variables are the size of the firm (Size: natural logarithm of total assets), financial leverage (Lev: total liabilities to total assets), age of the firm (Age: years since STAR Market listing), R&D intensity (RD: R&D expenditure/sales revenue) and revenue growth rate (Growth). Industry fixed effects at the two-digit level of CSRC classification and year fixed effects are added to all specifications.

4.3 Estimation Strategy

The two-way fixed-effects panel regression we use for this initial estimation is presented in Equation (2). Clustering of standard errors is used to address the serial correlation problem at the firm level. β_1 is the coefficient of the within-firm, year-adjusted partial effect of data resource operation intensity on financial performance after controlling for time-invariant firm heterogeneity and common year effects.

To address the problem of causality, we are now using a difference-in-differences (DID) model after the external shock in January 2024 for the accounting reform. Firms with DataOp scores above the sample median before 2024 are the treated group; those below the median are the control group. To check the parallel-trend assumption, an event-study specification is used to see if the pre-treatment coefficients are constant. A DID Design can help us know how much formalised data asset recognition has affected the change in financial behaviour and rule out other reasons for this change, such as macro-economic fluctuations and technology cycle changes in the sector. The post-treatment period is fiscal year 2024, and all previous years are considered the pre-treatment period.

5. Empirical Results

5.1 Baseline Regression Results

Table 1 is the baseline regression result. In the fully controlled specifications, Column (2) for ROA and Column (4) for Tobin's Q have a positive coefficient, and both are at the one-percent significance level. An increase of one standard deviation in DataOp (0.198 index units) is associated with an increase of 0.021 percentage points in ROA, which is about 50% of the mean ROA of 0.042 in the sample and is economically significant. Tobin's Q ($\beta = 0.693$, $p < 0.01$) is high; thus, the capital market believes that the operating data of the company contains a large amount of intangible option value and anticipates future revenue from the use of this data. Among the control variables, leverage has a negative impact on both indicators of performance and thus is over-leveraged. The research and development intensity of a company is positively related to its Tobin's Q, but it does not directly influence short-term ROA; this is in line with the time lag in the return of innovation investment shown by Brynjolfsson, Rock and Syverson (2021). Firm size is negatively correlated with ROA; that is, the upper quartile of STAR Market firms has diseconomies of administrative scale by total assets.

Table 1. Baseline Regression Results—DataOp and Firm Performance

	(1) ROA	(2) ROA	(4) Tobin's Q	(4) Tobin's Q
DataOp	0.019	0.021	0.521	0.693

(0.004)	(0.005)	(0.098)	(0.112)	
Size		-0.008		-0.124
(0.003)		(0.087)		
Lev		-0.034		-0.561
(0.009)		(0.142)		
Age		0.001		0.018
(0.002)		(0.031)		
RD		0.002		0.147
(0.003)		(0.039)		
Growth		0.011		0.093
(0.005)		(0.041)		
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
N	1,978	1,978	1,978	1,978
Adj. R^2	0.124	0.187	0.203	0.291

Notes. Standard errors clustered at the firm level are in parentheses. $p<0.01$, $p<0.05$, $p<0.1$. Columns (2) and (4) are the full controls. As shown in the coefficient of DataOp in Column (2), an increase of one standard deviation of DataOp (0.198 index units) will raise ROA by about 0.021 per cent. The relatively high value of Tobin's Q ($\beta = 0.693$) indicates that the capital market has priced in the intangible option value of data resources.

5.2 Mechanism Analysis

As shown in the text of the mediation analysis results, voluntary disclosure quality (VDI) and the SA financing constraint index are mediators. An increase in DataOp is positively correlated with VDI, and this is in line with disclosure theory; that is to say, companies that engage in more data-related activities have more material information to disclose and are subject to stronger reputational pressure to do so transparently. The coefficient of DataOp in the SA index is negative and statistically significant; thus, by expanding the scope of data operation, one can reduce the sense of financing risk by increasing the amount of collateral available to lenders in formally recognized and pledgeable data assets. With both mediators in the ROA model, the direct path of op decreased from 0.021 to 0.014, but it was still statistically significant. The above pattern is a partial mediation and supports Hypothesis 2.

5.3 Heterogeneity Analysis

Table 2 is the estimation results of heteroskedasticity based on firm size and technology certification. For the large-scale enterprise (total assets exceed the median of the sample), the DataOp coefficient for ROA is 0.026 ($p < 0.01$); for the small-scale enterprise, it is 0.011 ($p < 0.05$). It is due to the economy of scale in data infrastructure; that is to say, large enterprises can spread the fixed construction costs of data pipelines, quality governance systems and analytics talent over a large base of assets to achieve a higher marginal return per unit of DataOp. Tobin's Q is 0.781, and it was 0.572 before; thus, investors' valuation of a company will be lower without big data. Of the nationally certified high-tech enterprises, both the ROA coefficient and the Tobin's Q coefficient are relatively high compared with those of the non-certified group (0.028 vs. 0.009 for ROA and 0.891 vs. 0.512 for Tobin's Q). Therefore, it can be concluded that formal institutional endorsement of the technological situation may increase the

confidence of the market in the financial feasibility of data-intensive business models.

Table 2. Heterogeneity Analysis—Subsample Estimates

	(1) ROA (Large)	(2) ROA (Small)	(3) Tobin's Q (Large)	(4) Tobin's Q (Small)	(5) ROA (High-tech)	(6) ROA (Non-high-tech)	(7) Tobin's Q (High-tech)	(8) Tobin's Q (Non-high-tech)
DataOp	0.026	0.011	0.781	0.572	0.028	0.009	0.891	0.512
(0.006)	(0.005)	(0.134)	(0.109)	(0.007)	(0.004)	(0.156)	(0.098)	
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
N	989	989	989	989	1,186	792	1,186	792
Adj. R^2	0.201	0.152	0.312	0.247	0.219	0.143	0.337	0.258

Notes. Standard errors are clustered at the firm level and shown in parentheses. $p < 0.01$, $p < 0.05$, $p < 0.1$. "Large" ("small") firms are those with total assets above (below) the median of the sample, and "high-tech" firms are those that have obtained official national high-tech enterprise certification. All regressions are the full sets of control variables (Size, Lev, Age, RD, Growth) and fixed effects. The pair differences of the groups are statistically significant at the 5% level or better.

6. Discussion

All of the above results have all kinds of applications. Based on the above results, it can be concluded that in the background of the data economy, formally recognised data assets will be able to generate actual financial benefits after three to five years of accumulation. Partial mediation evidence indicates that it is a multi-channel model, and the improvement in enterprise performance can be due to both an increase in operating efficiency and direct product innovation, as well as the indirect optimisation of the information environment and reduction of financing costs. The J-curve dynamic of the estimated control variable is in line with previous research on the gestation period of intangible investment, and it can be concluded that cross-sectional studies conducted shortly after the implementation of the accounting reform may underestimate the long-term returns to data assets.

The Policy Implications are the same. China has been building a data governance system, declared data a new source of wealth and power, created a mandatory structured accounting system for data resources, established a data-element market, etc., all of which aim to build an all-encompassing system to benefit from data investment economically. The heterogeneity of the results shows that the transmission of policy is not uniform. Most small and medium-sized enterprises in the science and technology and innovation industry do not have the funds to build an official data governance system, so in cooperation with the science and technology department of the province, a tiered regulation approach will be taken

to simplify the disclosure form and other support measures will be provided, such as preferential tax policies for investment in data infrastructure and joint data certification schemes.

7. Conclusion

Analysing the changes in the financial behaviour of the 487 Chinese STAR Market-listed STI companies from 2019 to 2023 due to data resource operations is the objective of this paper. Based on the data of asset accounting reform in China as of January 2024 and a difference-in-differences identification strategy, it can be observed that an improvement in the level of data resource operation has had a positive and significant effect on both the return on assets and Tobin's Q. One of the reasons for this is that information will be relatively more transparent; that is to say, the quality of voluntary disclosure will be relatively high, and at the same time financing constraints will be reduced, which may be reflected in the SA index in line with the information asymmetry and signaling framework of Hypotheses 1 and 2. After heterogeneity analysis, most of the performance improvement in large enterprises and national high-tech certified enterprises is concentrated; thus, it can be concluded that both scale and institutional recognition may have increased the financial returns of data-intensive enterprises. Based on the above results, it can be seen that data governance will improve the accounting recognition of innovation-intensive enterprises, strengthen the quality of disclosure, and provide more effective market signals.

The following are some shortcomings. Although a five-year panel window is relatively long for the first causal analysis, it may not fully show the changing effects of the 2024 accounting reform at different stages of corporate reporting. The DataOp index is based on the textual disclosures in annual reports and may not fully reflect how far the actual extent of the depth of the data pipeline, cross-organizational data cooperation and the economic benefits of unregistered proprietary data held off-balance-sheet have been achieved. In the future, it is proposed that more direct indicators of data infrastructure be developed, such as the assessment of data pipeline architecture, data monetization revenue stream, cross-border data flow index, etc., to promote the strengthening of data disclosure standards in line with the new accounting provisions. Further studies will be carried out in 2025, and then more causal evidence will be provided for the path of continuous development of the financial performance of data-asset-intensive enterprises as the market for data elements matures and the regulatory system of data factor pricing changes constantly.

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