Data Assets and Market Power: Evidence from China

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Abstract. In the digital economy era, big data analytics (BDA) has become an important path for firms to gain competition advantage. As a key element of BDA, how does a firm's data assets affect its market power? This article uses machine learning and text analysis to construct the index of data assets, and use the panel data of Chinese A-share firms from 2010-2022 to examine the impact of data assets on market power. This paper finds that data assets can significantly enhance market power. The conclusion remains after considering endogeneity issues and conducting robustness tests. Non-state-owned firms, small-size firms and firms facing higher environmental uncertainty benefiting more from data assets within firm. The results of mechanism analysis indicated that data assets can enhance market power through mechanisms that improve the TFP and reduce customer con-centration. The conclusions of this paper help to accurately assess the market effects of firm's data assets and provide empirical evidence for policy making.

Keywords: market power, data assets, text analysis, digital economy

1 INTRODUCTION

With the development of artificial intelligence, big data and other digital technologies, the world has entered the era of digital economy. In the era of digital economy, the significance of data has become increasingly prominent. Data has been recognized as a resource which creates values for business and societies. More and more companies are gaining economic benefits by collecting, analyzing and processing their own data resources. In 2019, Data was formally put forward as a factor of production on the 4th Plenary session of the 19th CPC Central Committee. The value of data assets was highly affirmed.

Due to the wide application of digital technologies, data has penetrated every aspects of firms. Some firms achieved success which is attributed to their superior access to data and capabilities to exploit this resource [1]. How exactly does a firm's data assets affect its market power? Is there heterogeneity in the impact among different types of firms? And what are the impact mechanisms behind it? Accurate answer will not only help us to deepen the understanding of the role of data asset, but also provide empirical evidence and policy references.

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Our study contributes to the literature in the following ways. First, we extend the literature concerning the determinants of a firm's market power. Previous Literature documents internal and external characteristics such as product innovation [2], minimum wage [3], trade liberalization [4], etc. This article contributes to the literature by verifying an important determinant of a firm's market power – data assets. Second, we provide evidence about the market effect of data assets. The measure of data assets also provides reference for future research. In addition, this article also provides practical implications for firms and government regulators.

2 LITERATURE REVIEW AND HYPOTHESIS

Nowadays, different types of data have been widely used in every industry. However, data is not simply equal to data assets. According to CAICT, data assets are defined as "data owned or controlled by an enterprise and can bring future economic benefits to the enterprise". From the perspective of value, data does not produce benefits directly. The raw data could only release valuable information to the firm after four stages: data collection, data storage, data analysis and data application, which is referred to as the process of data capitalization. After this process, data can be converted into data assets. The development of digital technology has enabled firms to accumulate a huge amount of data in operation and management as well as analyze it. The accumulation and analysis of data, in turn, promotes the advancement of digital technology, forming a feedback loop. The deep integration of data and digital technology has profoundly changed production and life style, exerting a multi-faceted influence on corporates. Data has been the new oil in digital economy.

Market power refers to the firm's ability to significantly influence market prices. Market power is a fundamental problem in the field of industrial organization. It reflects the firm's performance and competitiveness. It is well known that Internet companies use price discrimination based on their user data. The monopolistic price-setting behavior increase the markup of the IT firms, which is a measure of the market power. But can firms in other industries establish market power based on their data assets? Some recent studies have attempted to explore its impact on different parameters, but they omitted a discussion on market power [5,6]. Data assets are crucial element of big data analytics and other digital innovations. Based on the resource-based view (RBV), existing literatures have indicated that data can be an important source of competitive advantage. Combined with managerial engineering and analytic skill, data can be transformed into information and knowledge, which can be a VRIN (valuable, rare, inimitable and non-substitutable) resource for a firm [7], thus lead to competitive advantage. By using big data technology to process and analyze data assets, companies can obtain more accurate knowledge and information, which is crucial for firms to survive in the highly competitive environment [8]. Therefore, data plays an important role in helping firms to outperform their competitors [9,10]. However, previous research focuses on theoretical research or case analysis, the empirical evidence is still lacking. According to the existing literatures, the possible mechanisms of influence of data assets on firm's market power can be summarized into the following two aspects.

First, data assets can improve productivity and management efficiency. Data assets contribute to the "data-driven decision-making"(DDDM), which is more advanced than intuition-driven decision making. Based on the appropriate production plan, firms can optimize the production flow and the allocation of resources. Eeckhout holds that data can reduce uncertainty and risk, and proposed a model in which economies of scale in data induce a data-rich firm to invest in producing at a lower marginal cost and larger scale [11]. Brynjolfsson found that firms that emphasize DDDM show 5-6% higher performance [12]. Farboodi holds that big data can increase information transparency within organizations, thereby improving the quality of decision-making [13]. In addition, data assets can reduce the trial-and-error cost of enterprises in the research and development process, promoting the technical investment and upgrading, which can also improve the total factor productivity. Higher productivity provides cost advantage to a firm, which can increase the market power. As much, this article proposes the following hypothesis:

Hypothesis 1: Data assets enhances firm's market power by improving the TFP (Total Factor Productivity).

Secondly, the accumulation of data assets increases the company's understanding of the market and reduces the company's sale costs and friction costs. Through the collection, processing and analysis of data from market and the feedback of customer, the firm can get customer's behaviors, pain point and so on, thereby provide more personalized products and services, as well as create personalized advertisements to expand the market [14]. Abis believes that the main role of data is to generate predictive knowledge of market [15]. In addition, firms can also strengthen the customer relationship management by making use of data assets. Based on above analysis, we expect that data assets can reduce the customer concentration. Customer concentration refers to the ratio of sales from the firm's most important customers to total sales. Customer concentration is a reflection of the firm's vertical market power. Kim found that customer concentration negatively affects the supplier's ROA and ROS [16]. The higher the concentration of customers, the higher the probability of core customers squeezing the economic profits [17]. In order to maintain the transactions with large-scale customer, a firm may have to accept a lower price. But the personalized products or services and the expansion of market can enhance the bargaining power of firms. Thus, we propose the following hypothesis:

Hypothesis 2: Data assets enhances firm's market power by reducing the customer concentration.

3 STUDY DESIGN

3.1 Model Settings

To verify the impact of data assets on the firm market power, the following model was constructed:

$$MKP_{i,t} = \beta_0 + \beta_1 Data_{i,t} + \gamma controls + \mu_i + \eta_t + \varepsilon_{i,t} \quad (1)$$

The explanatory variable, $MKP_{i,t}$, denotes the market power of firm i in year t; the core explanatory variable, $Data_{i,t}$, denotes the data asset of firm i in year t. To ensure the stability of the results, control variables ($controls$), industry fixed effects (μ_i) and time fixed effect (η_t) are included. $\varepsilon_{i,t}$ denotes the residual term. β_1 and γ are the regression coefficients of the core explanatory variables and the control variables.

3.2 Variable Measurement

Explanatory Variables. The quantitative measurement of data assets of firms is important to accurately estimate the impact of a firm's data assets. However, there isn't generally accepted method to assess the value of data assets. This method has difficulty in reflecting the full value of data assets. The value of data assets is mainly driven by the specific use case, rather than the ICT investment volume. Therefore, the text analysis method was introduced to measure the indicators that are difficult to measure in the past. Therefore, text analysis is employed in this paper to measure the indicator of data assets [18,19,20].

First, following Wei [19] and Hu [20], we constructed the data assets text dictionary. The process of data capitalization can be divided into four stages: data collection, data storage, data analysis and data application. We selected a serious of seed words related to the four stages, such as "data assets", "data resource", "data collection", "data analysis". We collected The White Paper of Data Elements and other papers and merged them into a corpus. To avoid missing keywords, the word2Vec model was employed to generate the expanded dictionary. We also manually checked all the words in the auto-generated dictionary and excluded the unfit words. We get a dictionary which contains 94 keywords at last. Table 1 shows the most frequent words. Secondly, we use Python crawler to acquire the annual reports of firms. Thirdly, the Jieba package is employed to perform word segmentation and count all word frequencies. Finally, we calculated the total word frequency of each word. We added 1 to the total word frequency and performed logarithmic processing, because the distribution of the indicator has a clear right skew.

Table 1. The most frequent keywords of data assets

Keywords Category	Keywords
Data Collection	dataset, data collection, data resource, customer information, network data
Data Storage	data center, data platform, data security, database, data system
Data Analysis	data analysis, data management, data mining, data technology, data
Data Application	data application, data usage, data trading

Data assets often come with a large-scale ICT investment, such as computing devices and communications devices. Therefore we verified the validity of the indicator of data assets by testing the correlation between the indicator Data and the fixed assets investment related to data assets, which is displayed in the following binned scattered plot.

As is shown in Figure1, there is a strong relativity between the two variables. The indicator reflects data asset within firms well.

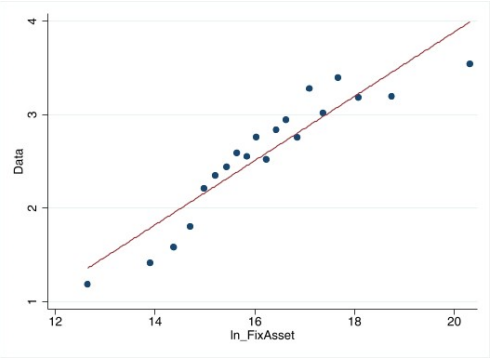

Fig. 1. The scatter plot between fixed assets investment and *Data*

Dependent Variable. The firm's market power is measured by its price markup. We followed the framework developed by De Loecker [21]. The company's markup can be written as:

$$MKP_{i,t} = \theta_{it}^{X}(\alpha_{it}^{X})^{-1} \tag{2}$$

where θ_{it}^{X} denotes the output elasticity of intermediate goods' input X, and α_{it}^{X} denotes the ratio of expenditure on input X to total output. The parameters of production function is estimated using the transcendental logarithmic production function. The specific settings are as follows:

$$\begin{aligned} y_{it} = \beta_l l_{it} \beta_m m_{it} + \beta_{ll}(l_{it})^2 + \beta_{kk}(k_{it})^2 + \beta_{mm}(m_{it})^2 + \beta_{lk} l_{it} k_{it} + \beta_{lm} l_{it} m_{it} \\ + \beta_{km} k_{it} m_{it} + \beta_{lkm} l_{it} k_{it} m_{it} + \varpi_{it} + \varepsilon_{it} \end{aligned} \tag{3}$$

where y_{it} is the output, l_{it}, k_{it}, m_{it} denote labor input, capital stock, and intermediate good's input. ϖ_{it} refers to the productivity parameter. ε_{it} refers to the random error term. Following the DLW method, we used a two-step estimation of Equation (3): first, we obtained the estimated values of the productivity by using the proxy variables of productivity; second, we used GMM method to estimate the parameters of Equation (3). The equation for the elasticity of intermediate inputs is:

$$\theta_{it}^{m} = \beta_m + 2\beta_{mm} m_{it} + \beta_{lm} l_{it} + \beta_{km} k_{it} + \beta_{lkm} l_{it} k_{it} \tag{4}$$

By substituting θ_{it} into Equation (2), we can get the firm markup rate.

Control Variables. We control for a series of firm-level variables, including Age, Size, Lev, ROA, Top1, TBQ. Table2 shows the definition of all variables.

Table 2. Variable Definition

Variable Types	Variable Name	Definition
Explained Variable	MKP	Price mark-up, calculated by DLW method
Explanatory Variable	Data	Data assets, ln (frequency of words related to "data assets" in the annual report+1)
Control Variables	Age	Ln(age+1)
	Size	Ln(assets+1)
	Top1	Ratio of shareholding of the largest shareholder
	Lev	Total debt/total assets
	ROA	Net profit/total assets
	TBQ	Tobin's Q, market value/total assets

3.3 Data Sources

In this paper, data of Chinese A-share listed companies from 2010 to 2022 are taken as the research sample. The micro-level and macro-level data was obtained from the CSMAR database and Wind Financial Terminal. The firm's annual report is collected from the website of Stock exchanges. To make the result more representative, the following data is excluded: (1) financial industry, ST and *ST companies; (2) companies with missing core explanatory variables. In addition, all continuous variables are winsorized within 5th and 95th percentiles to eliminate the potential impact on empirical results.

3.4 Summary Statistics

Table 3 shows summary statistics of the major variables. Data has a mean value of 2.447, a minimum value of 0 and a maximum value of 7.315, indicating that a significant difference of the data assets among different firms. MKP has a mean value of 2.345, which is in accord with existing literatures.

Table 3. Summary statistics

Variable	N	Mean	Std	Min	Max
MKP	26187	2.345	0.577	1.403	3.530
Data	26187	2.447	1.867	0.000	7.315
Size	26187	22.265	1.333	16.117	28.607
Age	26187	2.975	0.307	-0.089	4.224
ROA	26187	0.038	0.061	-0.230	0.204
Lev	26187	0.433	0.206	0.056	0.922
TBQ	26187	1.938	1.601	0.139	8.814
Top1	26187	0.340	0.150	0.084	0.743

4 RESULTS

4.1 Benchmark Regression

Table 4 reports the results of the benchmark regression of data assets on firm market power. Column (1) displays the regression result contains only industry and year fixed effects, and Column (2) display the regression results including the control variables. As shown in Column (1), the regression coefficient of Data was 0.104, which passes the 1% significance test. Moreover, the coefficient of Data is still significantly positive at the 1% level after including a series of control variables. Therefore, the aforementioned results support the conclusion that data assets can significantly enhance market power.

Table 4. Benchmark regression

Variable	(1)	(2)
Data	0.104***	0.032***
	(16.799)	(4.437)
Age		0.060**
		(2.736)
Size		0.314***
		(18.861)
ROA		0.627***
		(5.654)
Top1		0.167***
		(6.298)
TBQ		-0.025***
		(-3.113)
LEV		0.545***
		(15.916)
Constant	2.089***	-5.171***
	(137.392)	(-15.094)
Year& Industry	YES	YES
N	26187	26187
Adjusted R-squared	0.1994	0.7911

Note: ***, **, * denote statistical significance at 1%, 5%, 10% levels, respectively.

4.2 Robustness Test

Replacement of the Explanatory Variable. To verify our conclusions, we replace the explaining variable to measure firm data assets. Following existing studies, we use the proportion of word frequency of “data assets” to total number of words in the annual

report as the proxy variable, and reexamine the impact of firm data assets on market power, which is denoted by Data2. Column (1) of Table 5 shows the result of the robustness test. After changing the measure of explanatory variable, the regression coefficient of Data2 is 0.459, which is still significantly positive at the 1% level.

Replacement of the Dependent Variable. We use Lerner index as the proxy variable for market power. Following Peress [22], Lerner index is defined as:

$$Lerner = \frac{income - cost - sellexp - adminexp}{income} \tag{5}$$

As shown in Column (2) of Table 5, the regression coefficient of Data is 0.044, which is positive correlated with market power at 1% level, confirming the robustness of our result

Replacement of Regression Samples. In recent years, data assets have received more and more attention from the capital market. Therefore, the firms may have incentive to disclose more information about data assets in their annual report to raise stock price. As mentioned above, data was formally put forward as a factor of production in 2019. To reduce the possibility of strategic disclosure, the samples after 2019 are excluded. The results are presented in Column (3) of Table 5. The coefficient of Data still passed the 1% significance test.

Table 5. Robust Test.

	Replace explanatory variable	Replace dependent variable	Replace regression sample
Variable	(1)	(2)	(3)
Data		0.044***	0.025***
		(3.174)	(3.316)
Data2	0.459***		
	(3.588)		
CVs	YES	YES	YES
Constant	-5.242***	-0.140***	-4.968***
	(-15.583)	(-4.732)	(-14.282)
Year& Industry	YES	YES	YES
N	26187	26187	15434
Adjusted R^2	0.7852	0.5448	0.7810

Note: ***, **, * denote statistical significance at 1%, 5%, 10% levels, respectively

4.3 Endogeneity Test

In order to eliminate the influence of endogeneity issues, the number of telephones per hundred people in the province where the firm is located was chosen to construct the

instrumental variable. The number of telephones reflects the development of digital technologies and the data accumulation. However, it has little impacts on firm market power. Therefore, it satisfies both the requirement of exclusivity and the requirement of relevance. Following Nunn [23], we constructed the interaction term of the number of telephones per hundred people of each province in 1984 and the Internet users in the previous year as the instrumental variable, which is denoted by Tele. The results are shown in Table 6. The statistical values of the under-identification test (Kleibergen-Paap rk LM) is 43.44, and the weak instrumental variables test (Kleibergen-Paap rk F) is 43.39, indicating that there are no under-identification or weak instrumental problems. Therefore, data assets can still significantly enhance market power after considering endogeneity.

Table 6. Endogeneity Test

Variable	Data (1)	MKP (2)
Tele	0.0002***	
	(6.59)	
Data		0.456***
		(6.40)
CVs	YES	YES
Year& Industry	YES	YES
N	26187	26187
Kleibergen-Paap rk LM	43.44	
Wald F	43.39	

Note: ***, **, * denote statistical significance at 1%, 5%, 10% levels, respectively

4.4 Mechanism Analysis

The previous empirical results revealed that data asset enhance firm's market power. In this section, the stepwise regression method is adopted to test the channel mechanism of influence of data assets on firm's market power, mainly in terms of TFP and customer concentration.

The Mediating Effect Test of TFP. We adopt LP method to estimate the total factor productivity (TFP) of firms. Columns (1) (2) and (3) of Table 7 report the results of mediation effect of TFP. The Sobel Z statistic of TFP is 32.83, which significant at 1% level. The mediation effect of TFP (0.044*0.415) accounts for 57.5% of the total effect. The result verifies the Hypothesis1, indicating that data assets can significantly enhance a firm's market power by improving TFP.

The Mediating Effect Test of Customer Concentration. We adopt the proportion of sales revenue of the top 5 customers to the total sales revenue of firms as the proxy variable of customer concentration (CC). Columns (4) (5) and (6) of Table 7 report the

results of mediation effect of customer concentration. The coefficients are significance at 5% level, and Hypothesis2 is verified.

Table 7. Mechanism analysis

	MKP	TFP	MKP	MKP	CC	MKP
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Data	0.032***	0.044***	0.013***	0.032***	-0.710**	0.029***
	(4.437)	(3.428)	(6.871)	(4.437)	(-2.127)	(4.378)
TFP			0.415***			
			(35.24)			
CC						-0.002**
						(-2.396)
CVs	YES	YES	YES	YES	YES	YES
Year& Industry	YES	YES	YES	YES	YES	YES
Sobel Z			32.83***			6.347***
N	26187	26187	26187	26187	19138	19138
Adj R^2	0.791	0.465	0.929	0.791	0.109	0.787

Note: ***, **, * denote statistical significance at 1%, 5%, 10% levels, respectively

4.5 Additional Analysis

The impact of data assets on firm market power may not be homogeneous. Therefore, we further explore the differences in the impact among different types of firms, mainly in terms of enterprises property rights, firm size and environmental uncertainty.

Firstly, we divide the firms into SOEs (state-owned-enterprises) and non-SOEs. Compared with non-SOEs, the SOEs may have a more conservative leadership style, which may reduce the investment in big data technology and the absorbing capacity, thereby weaken the positive impact of data assets. The variable SOE equal to 1 if the firm is controlled by governments or governmental institutions, and 0 otherwise. Column (1) of Table 8 reports the results of grouping regression. The results suggest that data assets can significantly enhance the market power of SOEs and non-SOEs, but the positive effect of data asset is more significant in non-SOEs.

Secondly, from the aspects of firm scale, small-size firms typically have lower productivity. Therefore, the increase of data assets may have a lager positive impact on the market power via the TFP channel. In addition, large-scale firms already have a strong price power. As a result, it is hard to further increase the price. Column (2) of Table 8 reports list the results of regression. The coefficient of the interaction term Data×Size is negative, which suggests that the positive effect in small-size firms is more significant than the effect in large-size firms. In other words, data assets management is more important for small-size firms.

Thirdly, the environmental uncertainty may also increase the value of data assets. When facing high environmental uncertainty, the external information would become more complex and changeable [24]. As a result, the company will rely more highly on

data assets of its own. So we expect that the positive effect of data assets may be more significant in firms which face higher environmental uncertainty. Following Li [24], we construct the indicator EU, which is defined as the industry adjusted standard deviation of the residual of company sales revenue over five consecutive years. As is shown in Column (3), the coefficient of the interaction term Data×EU is significantly positive at the 1% level, which indicates the higher value for companies facing higher environmental uncertainty.

Table 8. Heterogeneity analysis

Variable	(1)	(2)	(3)
Data	0.0355***	0.074***	0.0238***
	(4.818)	(2.930)	(3.592)
Data×SOE	-0.013***		
	(-4.514)		
SOE	0.071***		
	(4.301)		
Data×Size		-0.002*	
		(-1.832)	
Size		0.319***	
		(19.501)	
Data×EU			0.005
			(4.844)
EU			-0.026***
			(-6.881)
CVs	YES	YES	
Constant	-5.095***	-5.286***	
	(-15.408)	(-15.688)	
Year& Industry	YES	YES	
N	26187	26187	
Adjusted R2	0.7918	0.7666	

5 CONCLUSIONS

This article uses machine learning and text analysis to construct the index of data assets, and uses the panel data of Chinese A-share firms from 2010-2022 to examine the impact of data assets on market power. This article reveals that the data asset within firms can significantly increase their market power. The conclusion remains after robustness tests and endogenous processing. The results of mechanism analysis indicated that data assets can enhance market power through mechanisms that improve the TFP and reduce customer concentration. In addition, a heterogeneity analysis suggests that the positive effect of data asset is more significant in non-state-owned enterprises, small-size enterprises and enterprises which face higher environmental uncertainty. Based on the above data analysis results, the following suggestions are put forward. First, the firms should attach great importance to the application of digital technology, accelerating the

accumulation of data assets. In the increasing fierce market competition, firms can generate business value from the data assets, and enhance their market power. Secondly, the greater market power of firm may cause the loss of social welfare. The government are supposed to pay close attention to the market effects of data assets, and prevent abuse of user data and the invasion of customers' privacy. Thirdly, the government should also promote the transaction of data assets to make full use of it.

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