Data Element Level and International Breadth——Empirical Research Based on Chinese DMNEs

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Abstract. The vigorous development of the digital economy around the world has given rise to the rise of digital multinational enterprises(DMNEs). Using data as the main production factor has become an important feature that distinguishes them from traditional multinational companies. Its different factor structures guide us to examine internationalization from a new perspective --- an important issue for multinational companies. Based on the data of 458 DMNEs listed in China from 2008 to 2022, this article empirically examines the impact mechanism of data elements of DMNEs on the international breadth and the mediating role of production enablement and resource allocation optimization. The study found that data elements have a positive impact on production enablement and resource allocation optimization, and both have a positive impact on promoting the international breadth of DMNEs. Mechanism analysis found that data elements can improve the total factor productivity and resource allocation efficiency of enterprises, achieve production empowerment and resource allocation optimization. Furthermore, it creates favorable conditions for the expansion of the international breadth of DMNEs. This paper studies the impact of data elements on the development of international breadth from the perspective of DMNEs taking data elements as the main production factor, and enriches related research and provides inspiration from the perspective of production enablement and resource allocation optimization.

Keywords: Digital multinational enterprise, International breadth, Enterprise data element level,Production empowerment,Resource allocation optimization

1 Intruoduction

The continuous emergence of digital technologies such as artificial intelligence, blockchain, cloud computing, big data, and the Internet of Things has created favorable conditions for the iteration of digital products and the growth of service demand, spurred the development of digital investment, and fundamentally changed the production technology, production factors and production methods promote the birth of multinational companies with digital characteristics. This kind of enterprise that relies on network platforms and digital technologies to realize virtual and intangible business models and organizational operations not only has diversified international businesses, but also is a professional digital enterprise engaged in digital content creation and providing digital services and solutions. Digital multinational enterprises(Hereinafter referred to as DMNEs) have bucked the economic downturn caused by the COVID-19 epidemic sweeping the world in 2020. Their development speed and asset growth rate far exceed that of traditional multinational enterprises, showing an astonishing development speed. In an environment where the digital economy promotes and empowers

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high-quality growth in international trade, DMNEs, as emerging forces, will become an important engine that promotes physical information exchange, promotes technological upgrading, and assists the development of the digital economy and cross-border trade.

Using intangible data as the main production factor is one of the important characteristics of DMNEs. It is also the fundamental characteristic that distinguishes DMNEs from traditional multinational companies that only use digital technology to empower them. The digital attributes and characteristics of DMNEs are the same as those of traditional multinational companies[1]. Different from the continuous demand and dependence of traditional multinational companies on tangible factors such as land, labor, and natural resources, DMNEs rely on their data elements as the foundation to achieve overall operation and maintenance. With a strong data element foundation, DMNEs have low-level capabilities. It has the advantages of cost, efficient iteration, convenient management and coordination, and forms a digital ecosystem through network synergy, connecting multiple nodes in multiple countries and markets, laying the foundation for efficient and rapid international expansion.

On this basis, the possible marginal contributions of this article are as follows: First, it enriches relevant research on the internationalization of DMNEs. Currently, research on digital multinational corporations is emerging. Some scholars have studied DMNEs from the perspective of multinational location selection[1] and international diversification[2]. However, international Two important international divisions, depth and breadth of internationalization, still lack attention and research. Second, this article studies and analyzes the impact of DMNEs on the international breadth from the new perspective of data element levels, introduces production empowerment and resource allocation optimization as an intermediary variable to conduct an in-depth exploration of the impact mechanism, and explores in detail the enterprises data elements level. The internal logic of broadening the international breadth of enterprises. Third, this article selects DMNEs that have developed strongly in the digital economy in recent years and have both digital and international characteristics for research. Using large sample panel data can more comprehensively reflect the relationship between the data elements level and the international breadth. It helps to improve the representativeness of the sample and obtain more generalizable research conclusions.

2 Theoretical basis and research hypotheses

2.1 The relationship between Enterprise data element level and International breadth

The data element is the most important production factor for DMNEs, and it is also the main reason why DMNEs are different from other traditional companies. Relying on the Internet information network, making full use of integrated digital platforms, big data traffic and other data resources can strengthen production, sales, management and other links to achieve full-process data connectivity, improve the overall operating efficiency of the enterprise and the collaborative efficiency of the upstream and downstream industry chains, thus Reduce business transaction costs. From a relationship network perspective, reductions in costs such as transportation, communication, and cooperation in business process links can strengthen internal and external links within the enterprise[3], thus lowering barriers for enterprises to enter overseas markets. From the perspective of user participation, the transmission speed of data elements without time and space restrictions can form a wide market coverage, which means

that DMNEs can obtain many user participation data and evaluation feedback in various national markets in real time, directly and frequently Contact with international end users[4], and rely on data analysis to quickly capture opportunities to enter new international markets [5]. At the same time, it can also provide a complete system for multinational companies to establish rules, data supervision, platform construction, legal protection, etc. [6], reducing additional costs and losses caused by geographical, cultural and institutional barriers. This allows DMNEs to effectively control costs and have stronger risk-taking capabilities in their multi-country expansion. Based on this, the hypothesis is put forward:

H1: The Enterprises data elements level of DMNEs can broaden the international breadth.

2.2 The mechanism of the effect of enterprise data element level and internationalbreadth

First, from the perspective of production empowerment, data itself has strong economies of scale. The non-competitiveness of data elements makes the marginal cost of increasing data input close to zero, so that the long-term average cost decreases with the increase of input [7, 8]. This means that DMNEs can enable the entire production process with extremely low marginal cost production factors and extremely fast factor endowment fission, establish an international relationship network on the basis of enabling production, and rely on data assets to drive the internationalization of supply chains and production chains [9]. The application of new technologies such as big data, cloud computing, blockchain, and the Internet of Things all rely on the accumulation of data elements. The increase in the accumulation speed of original production factors driven by scale effects will promote the technological progress of enterprises, and then help enterprises to form capital accumulation, providing strong guarantees for the internationalization of business promotion and R&D expansion.

H2: The Enterprises data elements level of DMNEs can broaden the international breadth through production empowerment.

Secondly, from the perspective of resource allocation optimization, big data applications and accurate platform data can accurately collect various user preference information, get rid of the channel control of middlemen, and achieve more accurate resource allocation. For example, industrial Internet platform companies that are driven by digital technology and whose main business is to provide digital solutions can provide digital transformation and digital empowerment services to enterprises in various industries in different countries based on their own extremely high resource allocation efficiency[10]. Such DMNEs can obtain customer feedback in a timely manner, provide solutions based on the diverse and personalized needs of customers, promote customized and flexible production. The optimization and improvement of resource allocation brought by data elements can enhance the adaptability of enterprises in different national markets. When the host country environment changes, enterprises can reconfigure resources to deal with potential risks at a relatively low cost. In addition, digital products or digital components that support the normal operation of digital platforms and digital infrastructure have the characteristics of reprogrammability, reconfigurability, and openness[11]. Based on this, hypothesis H3 is proposed:

H3: The Enterprises data elements level of DMNEs can broaden the international breadth by optimizing resource allocation.

3 Research methodology and measurement

3.1 Sample screening and data sources

This article uses DMNEs listed in China as research samples. The research data in this article are all from the CSMAR database and Wind database. The corporate annual reports are crawled from the Juchao Information Network through Python. First, we obtain the list of China's listed multinational companies based on the CSMAR financial database and the "Directory of Chinese Enterprises' Overseas Investment" issued by the Ministry of Commerce. We also obtain data on finance, industry codes, main businesses, overseas subsidiaries, and the number of countries distributed through the CSMAR database. Then, based on the "World Investment Report 2017", four types of DMNEs, including Internet platforms, digital solutions, e-commerce and digital content, are specially distinguished, mainly based on the industry type and main business of the company. Finally, 458 Chinese DMNEs were sampled from 2008 to 2022.

3.2 Model setting

In order to examine whether the level of data elements of DMNEs has an impact on the breadth of internationalization, this paper constructs the following two-way fixed effect model:

$$NOS_{it} = \alpha_0 + \alpha_1 Del_{it} + \beta_1 controls + \Sigma Firm + \Sigma Year + \varepsilon_{it} \quad (1)$$

$\mathrm{NOS_{it}}$ represents the international breadth of enterprises i in year t; $\mathrm{Del_{it}}$ represents the data element level of enterprise i in year t; $\mathrm{controls}$ represents a series of control variables. In addition, $\Sigma\mathrm{Firm}$ and $\Sigma\mathrm{Year}$ represent enterprise individual fixed effects and time fixed effects respectively, ε_{it} represents random disturbance terms.

3.3 Variable setting

3.3.1 Dependent variable

International breadth. This article draws on the research[12, 13] and uses the number of overseas subsidiaries (NOS) and the number of countries in which overseas subsidiaries are distributed (NOC) to measure the breadth of internationalization of enterprises, in which NOC is used as a replacement indicator and is put into robust test.

3.3.2 Independent variables

Enterprise data element level (Del). An enterprise's artificial intelligence technology level, blockchain technology level, cloud computing technology level, big data technology level, and big data technology application level represent its ability to collect, store, clean, analyze, transform and utilize data elements. Therefore, drawing on the research[14], the subdivision indicators of the five indicators of artificial intelligence technology level, blockchain technology level, cloud computing technology level, big data technology level, and big data technology application level are calculated in the corporate annual report. The number of disclosures, and the level of investment in data elements is measured by summing the number of disclosures of all indicators. The higher the frequency of the five indicators appearing in the annual report, the higher the level of data element utilization of the company.

3.3.3 Mediating variables

Enterprise total factor productivity (TFP). In order to avoid endogeneity problems in variables as much as possible, this article adopts the LP method and OP method, which are currently most commonly used in empirical research in the micro field, and uses the Cobb-Douglas production function to measure the enterprises'TFP, represented by TFP_LP and TFP_OP respectively.

Resource allocation optimization. Resource allocation efficiency (Ineff) is used as a proxy variable. This paper draws on the measurement method[15] and uses the following model to calculate the impact of the company's growth opportunities, company size, asset structure, cash flow, company age, stock market return rate and new investment in the previous period, and finally takes the absolute value of the residual of the model to measure:

$$Ineff_{it} = \beta_0 + \beta_1 Growth_{i,t-1} + \beta_2 Size_{i,t-1} + \beta_3 Lev_{i,t-1} + \beta_4 Cash_{i,t-1} + \beta_5 Age_{i,t-1} + \beta_6 Ret_{i,t-1} + \beta_7 Invest_{i,t-1} + \Sigma Year + \varepsilon_{it} \quad (2)$$

The larger the value, the worse the efficiency of enterprise resource allocation; conversely, the larger the value, the more efficient the enterprise resource allocation.

3.3.4 Control variables

The accumulation of data elements by DMNEs requires high resource and cost consumption. Therefore, enterprises need to prepare certain resources and capabilities to promote the continuous accumulation of data elements. This article controls: (1) Firm size (Size) is the natural logarithm of total assets; (2) Firm age (Age) is the age of the business since its inception (3) Return on assets (ROA), (4) Growth (Growth) is total operating income growth rate (5) Asset-liability ratio (Lev) is ratio of total liabilities to total assets (6) The integration of the two positions(Dual), whether the chairman and general manager are held by one person; (7) Equity concentration (TOP10) is the sum of the shareholding ratios of the top ten shareholders.Table 1 shows the descriptive statistical results of main variables.

Table 1: Descriptive statistical results of main variables

VarName	Obs	Mean	SD	Min	Median	Max
NOS	3211	2.7683	5.354	0.00	1.00	40.00
Del	3211	2.5825	1.529	0.00	2.71	6.30
TFP_OP	3211	6.5656	0.817	4.30	6.44	10.79
TFP_LP	3211	8.2569	0.986	5.80	8.16	12.62
Ineff	2925	0.1255	0.124	0.00	0.09	1.64
Size	3211	22.0152	1.138	19.49	21.87	26.45
Age	3211	2.8208	0.360	1.10	2.83	3.61
Lev	3211	0.3656	0.183	0.03	0.36	0.91
ROA	3211	0.0413	0.077	-0.37	0.04	0.25
Dual	3211	0.4042	0.491	0.00	0.00	1.00
Growth	3211	0.2217	0.423	-0.62	0.15	4.12
TOP10	3211	59.0126	14.439	22.13	60.51	90.97

4 Empirical results and analysis

4.1 Baseline regression

Table 2 shows the baseline regression results. Before the empirical test, Stata16 has been used to pass the Hausman test, and the P value is 0.000. The test result is significant, so this article uses the fixed effects model to carry out empirical research.

The baseline regression results are shown in column (1) of Table 3 and do not include control variables. Columns (2) and (3) progressively control for individual and time fixed effects based on column (1). Column (4) contains the control variables and controls for individual fixed effects. Finally, column (5) uses model (1) to perform two-way fixed effects on the basis of including control variables to test the impact of the level of enterprise data elements on the breadth of internationalization. It can be seen that the regression coefficient between the level of enterprise data elements and the breadth of internationalization is 0.254 ($p<0.01$). At the same time, the regression coefficients of the level of data elements in the five models in the table below all reach $p<0.01$ under different conditions, which effectively illustrates that The level of enterprise data elements promotes the international breadth. This is because data elements, as the main production factors of DMNEs, can fundamentally enable companies to have stronger adaptability to the international market, thereby achieving multi-country expansion and efficiently promoting global business expansion. It can be seen that hypothesis H1 is verified.

Table 2: Baseline regression results

	(1) NOS	(2) NOS	(2) NOS	(3) NOS	(4) NOS
Del	0.731***	1.050***	0.448***	0.176**	0.254***
	(0.060)	(0.068)	(0.087)	(0.083)	(0.086)
Size				2.185***	2.282***
				(0.153)	(0.158)
FirmAge				0.232	0.522
				(0.467)	(0.921)
Lev				-0.422	-0.866
				(0.665)	(0.672)
ROA				-1.539	-1.647
				(1.017)	(1.020)
Dual				-0.134	-0.115
				(0.186)	(0.185)
Growth				-0.656***	-0.552***
				(0.154)	(0.158)
TOP10				-0.011*	-0.011*
				(0.006)	(0.006)
cons	0.881***	-0.001	1.375**	-49.927***	-45.674***
	(0.181)	(1.077)	(0.691)	(3.018)	(3.676)
Firm FE	NO	YES	YES	YES	YES
Year FE	NO	NO	YES	NO	YES
N	3211	3211	3211	3211	3211
r2	0.044	0.664	0.142	0.705	0.208
F	146.054	11.892	30.268	14.101	32.519

Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.2 Robustness test

Although the above empirical results show that the enterprise data elements level of DMNEs has a significant promoting effect on the international breadth. However, this correlation may

originate from their own factors, comparison bias, or unreasonable selection of indicators. Therefore, this article uses the following method to conduct robustness testing.

Table 3: Robustness test results

	(1) NOS	(2) NOS	(3) NOC	(4) L.NOS	(5) L2.NOS	(6) NOS
DIA	0.044***					
	(0.011)					
Dig		0.003***				
		(0.001)				
Del			0.092**	0.327***	0.360***	0.254***
			(0.041)	(0.094)	(0.104)	(0.086)
_cons	-45.498***	-50.565***	-23.953***	-40.701***	-31.299***	-50.500***
	(3.659)	(4.276)	(1.740)	(4.442)	(5.263)	(4.301)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	3211	2977	3211	2652	2230	3211
r2	0.210	0.203	0.261	0.215	0.196	0.711

Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.2.1 Replace the dependent variables and the independent variables

This article uses the proportion of the digital technology-related parts of the year-end intangible assets details to the total intangible assets (DIA)[16] and the company's annual number of digital technology patent applications (Dig) as substitute variables for the explanatory variables; the company The number of countries where overseas subsidiaries are distributed in that year [17][18]is used as a substitute variable for the explained variable and is regressed sequentially. According to the results of column (1), (2) and (3) in Table 3, the significant regression coefficients of enterprise data element level and international breadth after variable replacement are consistent with Table 3, indicating that the research conclusion has a positive impact on the variables. Different measurement methods remain robust, and the hypotheses of this article still hold.

4.2.2 Explanatory variables are lagging

In order to solve the endogeneity problem caused by the possible mutual causation between the explanatory variables and the explained variables, this paper uses the explained variables lagged for one period and two periods for regression analysis. The regression results are shown in columns (4) and (5) of Table 3.. It can be seen that the sign and significance of the regression coefficients of enterprise data element level and international breadth are basically consistent with Table 3, indicating that mutual causation has little interference on the research conclusion.

4.2.3 Transformation model

Considering that model selection may have an impact on the research conclusions, hybrid OLS was used for verification in the robustness test. The results in column (6) of Table 3 show that

after transforming the model, the signs and significance of the regression coefficients of the main variables remain unchanged, indicating that the research conclusions are robust.

4.3 Machanism test

4.3.1 Production empowerment mechanism

To verify that the data element level of DMNEs can broaden their international breadth by empowering corporate production, this paper uses the mediation effect test method to set the following stepwise regression model:

$$TFP_{it} = \alpha_0 + \alpha_1 Del_{it} + \beta_1 controls + \Sigma Firm + \Sigma Year + \varepsilon_{it} \quad (3)$$

$$NOS_{it} = \alpha_0 + \alpha_1 Del_{it} + \alpha_2 TFP_{it} + \beta_1 controls + \Sigma Firm + \Sigma Year + \varepsilon_{it} \quad (4)$$

First, model (2) is used for testing. The regression results are shown in columns (1) and (3) of Table 4. The regression coefficients of the data element level and the enterprises' TFP calculated by the OP method and the LP method are 0.024 ($p < 0.01$) and 0.032 ($p<0.01$), respectively, indicating that the data element level of DMNEs helps promote production empowerment. Further, this paper uses model (4) to test the mediating effect of production empowerment between the data element level and the international breadth. The test results are shown in columns (2) and (4). The regression coefficients are 0.245 ($p < 0.01$) and 0.227 ($p < 0.01$), respectively, indicating that production empowerment plays a mediating role between the data element level of DMNEs and its international breadth, and H2 is empirically supported.

Table 4:Mechanism result

	(1) TFP_OP	(2) NOS	(3) TFP_LP	(4) NOS	(5) Ineff	(6) NOS
Del	0.024***	0.245***	0.032***	0.227***	-0.006**	0.239***
	(0.008)	(0.086)	(0.009)	(0.086)	(0.002)	(0.092)
TFP_OP		0.393*				
		(0.201)				
TFP_LP				0.842***		
				(0.192)		
Ineff						-1.698**
						(0.754)
_cons	-2.548***	-44.673***	-4.084***	-42.234***	-0.048	-46.470***
	(0.349)	(3.709)	(0.365)	(3.746)	(0.112)	(4.196)
Controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
N	3211	3211	3211	3211	2925	2925
r2	0.614	0.209	0.667	0.213	0.071	0.198

Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.3.2 Resource allocation optimization mechanism

In order to study the data element level of DMNEs, we can broaden their international breadth by optimizing resource allocation, and build the following model:

$$Ineff_{it} = \alpha_0 + \alpha_1 Del_{it} + \beta_1 controls + \Sigma Firm + \Sigma Year + \varepsilon_{it} \quad (5)$$

$$NOS_{it} = \alpha_0 + \alpha_1 Del_{it} + \alpha_2 Ineff_{it} + \beta_1 controls + \Sigma Firm + \Sigma Year + \varepsilon_{it} \quad (6)$$

The results are shown in Table 4. Column (5) shows the regression results of model (5). It can be seen that the regression coefficient of variable Del on the intermediary variable Ineff is significantly negative, indicating that the data elements level has a significant negative impact on enterprise resource allocation efficiency. According to model (6), in column (6), the coefficient of the mediating variable Ineff on international breadth is significantly negative. The above results show that the intermediary role played by corporate resource allocation efficiency is significantly established. Based on the above, it can be seen that the data elements level has the function of improving resource allocation optimization, H3 is empirically supported.

5 Heterogeneity Analysis

Heterogeneity analysis is carried out from two perspectives. First, the test of equity heterogeneity. SOE=1 indicates a state-controlled enterprise, and SOE=0 indicates a non-state-controlled enterprise. The regression results in columns (1) and (2) of Table 5 show that the regression coefficient between the data element level of state-owned DMNEs and the international breadth is 0.644 ($p<0.01$) and significant, while the data elements of private DMNEs. The regression coefficient between level and international breadth is 0.005 ($p>0.1$) and is not significant. The above results show that the data elements level improves the international breadth of state-owned DMNEs, but has no significant impact on private DMNEs. This may be because state-owned enterprises can rely on a large amount of national resources to support their data element development and international expansion.

Table 5: Heterogeneity Analysis result

	(1)	(2)	(3)	(4)	(5)
	SOE=1	SOE=0	East	Mid	West
Del	0.644***	0.005	0.873**	0.199**	0.151
	(0.214)	(0.090)	(0.386)	(0.093)	(0.249)
Controls	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
N	2416	628	2787	152	272
r2	0.192	0.282	0.395	0.209	0.361

Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Second, regional heterogeneity test. Grouping dummy variables are introduced based on whether the company's registered address belongs to the eastern region, western region, or central region. It can be seen from columns (3) and (4) of Table 5 that when the enterprise is located in the eastern region and the central region, the regression coefficients are 0.873 ($p<0.01$) and 0.199 ($p<0.05$) respectively, indicating that the data elements level located in the eastern region has a significant impact on The positive effect of international breadth is the most obvious, followed by the central region, while the level of enterprise data elements in the western region is not significant on the development of international breadth. This may be because the eastern

and central regions themselves have better market conditions and institutional guarantee advantages. Compared with the western region, they have obvious advantages in the development level of digital technology. At the same time, their geographical transportation and innovation advantages also make it easier for enterprises to achieve For external expansion.

6 Conclusion

Based on the information of 458 Chinese DMNEs from 2008 to 2022, this paper studies the impact mechanism of the level of enterprise data elements on the international breadth. The study found that the level of data elements can promote the expansion of international breadth through production empowerment and resource allocation optimization. After endogenous discussion and robustness test, this conclusion still holds. Finally, heterogeneity analysis found that for state-owned holding enterprises and enterprises located in the eastern and central regions, the impact of data element level on international breadth is more obvious.

In the future, DMNEs should establish and improve data security management systems, strengthen the application of technical means such as data encryption, backup and recovery, and strengthen the protection mechanism of their own data elements. At the same time, it is necessary to adjust and optimize the internationalization strategy in a timely manner, promote the transformation of data elements of their own underlying digital technologies, consolidate their own digital capability advantages as "born digital" enterprises, and lay a solid foundation for the internationalization process of sustainable development.

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