Research on the Impact of Digital Transformation on Manufacturing Enterprise Performance

Jinchao Guo[1], Huimin Tan[2], Gelegjamts Adilbish[1(✉)], and Fengjie Wang[2]

[1] Graduate School of Business, The Graduate University of Mongolia, Ulaanbaatar, Mongolia
mdguojinchao@xhsysu.edu.cn, gelegjamts_teach@yahoo.com
[2] School of Management, Guangzhou Xinhua University, Guangzhou, China

Abstract. Research on the relationship between intelligent upgrading and the performance of manufacturing enterprises has been widely concerned by academia; however, the relationship between the two and the mechanism of influence has not yet reached a consistent conclusion. Digital transformation has a huge impact on manufacturing enterprises, including organizational change, enterprise performance and so on. However, the existing research only explores the impact of individual factors on corporate earnings; and lacks the analysis of the overall linkage effect of all factors. This paper analyzes the success factors of digital transformation by investigating 232 manufacturing enterprises in the Guangdong-Hong Kong-Macao Greater Bay Area of China. The study finds that the digital transformation is the only way for enterprises to enhance their core competitiveness; and demonstrates that after the real digital transformation, the innovation ability of enterprises is improved, the operating cost is reduced and the production efficiency is improved. Simultaneously, the moderating effect of entrepreneurs' cognitive level is expounded.

Keywords: Digital transformation · manufacturing enterprises · influence mechanism

1 Introduction

According to the latest White Paper on China's Digital Economy Development (2021), China' s industrial digitization will reach 37.18 trillion yuan in 2021, an increase of 16.2% year-on-year, accounting for 81.7% of the digital economy and 32.5% of GDP. The data show that the birth of the digital economy due to the digital transformation of manufacturing enterprises has become a new economic growth pole in the future. Unicorn enterprises at the top of the pyramid, with high cognitive levels and strong learning ability, have already entered the fast lane of the digital economy. Small and medium-sized enterprises that lack capital flow are not willing to lag behind, actively integrate into the industrial Internet, and strive to achieve business process data transparency. Especially in the context of China, a large number of large-scale manufacturing enterprises such as Huawei and Midea that have succeeded in digital transformation often emerge. These

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successful cases provide a scientific reference for building a digital ecosystem. From the perspective of social services, the digitization process has promoted the reshaping of the value chain, such as mobile payment, government office, epidemic prevention and control, and social media. Enterprises that have implemented digital management have continuously improved their execution efficiency and continuously optimized their supply chain solutions. These practices show that digital reform has shifted from focusing on a single link and functional department organization to reshaping the whole process and link of the entire value chain. It can be seen that digital transformation has become a catalyst for the deep integration of virtual economy and real economy. It is always the mission to create value around national needs, leading economic growth and achieving common prosperity.

2 Literature Review

2.1 Digital Transformation and Enterprise Core Competence Upgrading

Digital transformation refers to the use of IT technology to optimize business processes, making the production more efficient and effective [1], thus creating more value of an enterprise organizational change activities (Vial, 2019; fischer et al., 2020) [2]. Digital transformation will drive the change in product quality, the improvement of organizational efficiency and the persistence of innovation, and promote the intelligent development of the industry by constantly meeting the individual needs of customers. The improvement of a company's core competencies mainly come from the continuous upgrading of its organizational management capabilities (Demirkan et al., 2016) [3], especially despite of major emergencies such as an epidemic. Therefore, traditional manufacturing enterprises want to participate in the formulation of game rules for the survival of the fittest through digital means, so they have improved the cognitive level of senior managers, organizational learning ability, and continuously enhanced the vitality of enterprises. Research on digital transformation and enterprise performance mainly focuses on these aspects: accelerating the process of digital management through organizational learning, embedding ERP software in business processes, and creating an intelligent Internet platform (Girod and Whittington, 2017) [4]; simultaneously, the improvement of core competence is the inevitable result of digital transformation (Du et al., 2016; vial, 2019) [5]. This discussion further confirms that the digital transformation promotes socialized division of labor, improves the internal structure of the organization, makes the organization flatter; and creates favorable conditions for resource co-creation and sharing. Under the epidemic crisis, through digital technology, it not only improves the organizational resilience of enterprises, realizes the transparency of supply chain process data, ensures that enterprise performance remains unchanged, and then survives. It can be seen that through multi-dimensional analysis, digital transformation has been particularly significant in improving corporate performance, enhancing corporate core competence and organizational resilience (Prajogo and Olhager, 2012; paunov and Rollo, 2016) [6, 7]. However, the specific mechanism of the two in the process of change requires in-depth corporate research to obtain data to solve the puzzle.

2.2 Influence of Digital Transformation on Enterprise Dynamic Core Competence

In a global context full of competition and complexity, the digital transformation can bring huge benefits to manufacturing enterprises, including organizational change, enterprise performance and other aspects; however, the existing research only explores the impact of a certain factors on corporate performance; and lacks the analysis of the overall linkage effect of all factors. Therefore, based on the relevant variables that affect performance, this paper provides a unique research framework to explore its impact mechanism from the perspective of the value creation process.

In practice, with the continuous improvement of the organizational learning ability of enterprises, managers realize the value of the integration of IT technology and business process; and strive to build a path system of "digital transformation motivation-intermediate adjustment effect-optimization performance". In short, the digital transformation should follow the principle of the knowledge spillover effect, and generate enterprise performance through continuous imitation and independent innovation [9]. The specific performance in the following path: continuous innovation, reduced transaction costs, through accurate customer demand forecasting, the use of industrial interconnection means; and constinuously improved production efficiency. The specific logical framework is shown along Fig. 1.

1) Digital transformation improves enterprise performance through continuous innovation.

In today' s business community, product homogeneity is more and more serious, only concerned about the scale of production enterprises are difficult to adapt to the new market demand. When the external market environment has undergone tremendous changes, manufacturing companies should actively promote business model changes, from marketing to product design; and implement a comprehensive innovation model. The connotation of continuous innovation should also be manifested in the following aspects, to build various media sharing interactive marketing platform, and constantly shorten the time and space distance with customers, and suppliers, real-time grasp of the

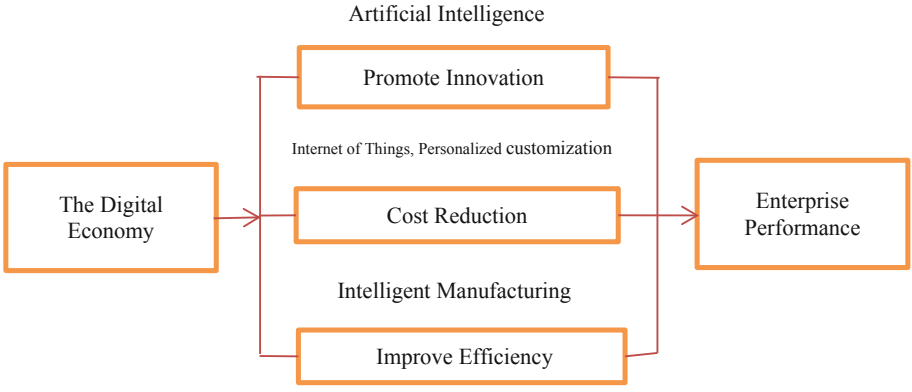

Fig. 1. Mechanism of digital transformation and performance of manufacturing enterprises

supply chain product flow status, information processing and taxation and other capital turnover efficiency. In this digital era of collaborative change, upstream and downstream participants, such as suppliers, core enterprises and customers, should establish efficient cross-border communication mechanisms to allow supply chain members to participate in value creation. Based on this, we finally realize the continuous innovation of R&D, design, production, sales, and demand forecasting methods, and continuously enhance the customer's sense of experience, thus effectively improving the overall performance of the enterprise.

2) Digital transformation improves performance by reducing transaction costs.

In the era of self-media marketing, enterprises must establish a strong link with consumers and rely on Internet technology to achieve sales breakthroughs. Taobao' s "Double Eleven" sales record for 2021: complete sales of 1 billion yuan in only 52 s (72 s in previous years); achieved sales of 10 billion, only 6 min and 58 s; day trading volume reached 120.7 billion, trading across more than 200 countries or regions around the world. Enterprises exist because of customers. They must closely focus on customer needs and constantly create customer-delivered value. The intensity of customer interaction determines the developmental prospect of an enterprise. In Xiaomi, Apple and Huawei's cloud community model, the platform gives full play to the participation of customers, customers continue to be inspired by the enthusiasm for the creation, thus shortening the time and space of communication between enterprises and customers, to establish a s strong link relationship. For example, Xiaomi Company founded the Xiaomi Community, which covers community life, product design, after-sales service, member feelings and other layouts. From the initial more than 100 members, it has developed millions of fan members and collected much innovative inspiration for improving Xiaomi series products. Therefore, through data sharing and interaction, it not only meets the individual needs of customers, establishes a dynamic flexible value network, quickly responds to the consumer market; but also saves huge marketing advertising costs and improves enterprise performance.

3) Digital transformation improves operational efficiency through intelligent decision-making.

Under the principle of social division of labor, most traditional manufacturing enterprises pursue standardized production, and use a scale effect to reduce unit production costs in the short term. However, in the era of intelligent manufacturing, enterprises in addition to reducing production costs, improving product quality and delivery efficiency, more important problem is how to resolve the contradiction between personalized needs and large-scale manufacturing costs. In 1996, Midea began implementing the ERP system, comprehensive construction of business processes as the main body of the IT system, covering the product manufacturing plan (MPS), advanced planning and scheduling (APS), supplier relationship management system (SRM), customer relationship management system (CRM), human resources management system (HRMS) and financial management system (FMS). After several years of efforts, turnover soared from 138.4 billion yuan in 2015 to 341.2 billion yuan in 2021, with a net profit of 28.6 billion yuan. All of these results, due to the United States through IT technology and business process depth of integration, and constantly improve operational efficiency, follow the principle of creating value with customers, to achieve excellent results. Therefore, through

the "artificial intelligence + Internet technology + business process" strategy, enhances product manufacturing collaboration, accelerates product update iteration speed, to meet the individual needs of customers, thereby enhancing the core competence of enterprises, thereby improving business performance.

Based on the above analysis, this paper proposes the following assumptions:

- H1: Digital transformation can improve the performance of manufacturing enterprises;
- H2a: Digital transformation reduces R&D costs and improves corporate performance through continuous innovation;
- H2b: Digital transformation reduces transaction costs and improves corporate performance through digital marketing;
- H2c: Digital transformation improves operational efficiency and corporate performance by implementing information systems.

3 Research Design

3.1 Data Sources

To improve the objectivity and effectiveness of the sample, this study uses WeChat, e-mail and other online methods to conduct research, combined with field visits, multi-channel data collection. Simultaneously, make full use of official statistics, with reference to the annual report published by listed companies, to build research data sets. Research objects for the Guangdong-Hong Kong-Macao Greater Bay Area manufacturing enterprises, mainly in the Pearl River Delta enterprises, more representative, accounting for more than 90%. Questionnaire respondents or interviewees of the sample enterprises in the senior management, have been exposed to the digital transformation business, more familiar with information technology. In this study, 365 questionnaires were distributed and 232 were recovered, with an effective recovery rate of 63.5%. The specific distribution of manufacturing enterprises in Guangzhou, Shenzhen, Zhuhai three cities, the enterprise scale span a wide range between 1 million and 100 billion. In terms of the nature of the enterprise, state-owned enterprises account for 25%, private enterprises account for 65%, and other joint-stock enterprises account for 10%. Generally, the sample sources are diversified, almost covering the research elements such as industry attributes and business scope required by the research. The item design is more objective. Simultaneously, the digital cognition level of the respondents is high, which lays a solid foundation for collecting high-quality questionnaires.

3.2 Model and Variable Definitions

Enterprise performance is a dynamic business evaluation index, drawing on previous research results, based on business data recently years, to further measure the effect of digital applications, created the following model:

$$Per_{it} = H + \alpha_1 \times AP_{it} + \sum_j \gamma_j \times control_{j,it} \quad (1)$$

In the model, Per_{it} is the business achievement or enterprise performance of the *i-th* enterprise in the *i-year*, AP_{it} is the digital transformation level of the *i-th* enterprise in the *i-year*, $control_j$ are control variables, and H is a constant term.

$$Q_{it} = H + \beta_1 \times AP_{it} + \sum_j \gamma_j \times control_{j,it} \tag{2}$$

$$Per_{it} = H + \beta_2 \times Q_{it} + \sum_j \gamma_j \times control_{j,it} + \varepsilon_{it} \tag{3}$$

In the model, Q_{it} is the digital transformation path of the *i-th* enterprise organization in the *i-year*. The purpose is to measure the factors influencing the enterprise transformation path in different periods. Formulas (2) and (3) are used to measure and test whether the Q variable is regulated by intermediary variables such as executive cognition and transformation path under the premise that Formula (1) is established.

It can be seen from the above formula that the explained variable enterprise performance is expressed by the profit rate, that is, the ratio of operating profit to average total assets; as an important control variable, the scale of enterprises is reflected by the number of employees, turnover and total assets. After correlation analysis, the two are closely related; the debt ratio reflects the operating efficiency of enterprises, directly reflects the solvency of enterprises and cash flow status; in addition, the company's establishment time, transnational operation, or foreign trade (usually $export = 1$, $non\text{-}export = 0$) is also important performance indicators. The mediating variables are elaborated from three aspects: continuous innovation ability (R&D investment ratio, patent number), transaction cost (ratio of transaction cost to operating income); and production efficiency index (ratio of input and output). It can be seen that in order to more accurately measure the digital transformation effect, the following variables are described, as shown in Table 1.

4 Analysis of Empirical Results

4.1 Descriptive Statistics

The scale refers to the mature scale of digital research, and the measurement items draw on the latest research results. Table 2 shows the digital technology change of 232 sample enterprises. Of the 232 companies surveyed, ERP systems were implemented over the past five years (2017–2021), accounting for 75.12% of the total. Among them, the measurement standard takes the number of ERP modules as the indices, including five modules: manufacturing, customer relationship management, supplier relationship management, financial accounting and human resource management. The average implementation ratio of each enterprise module is 1.821 items, of which the number of application items of OEM manufacturing enterprises is 0.786, and the number of R&D enterprises is 1.032. According to the classification and evaluation of industry ownership, the digitization rate of private enterprises is 78.26%, and the digitization rate of public enterprises is 67.57%, indicating that private enterprises in the Pearl River Delta are more active in the digital transformation, and the average number of module applications is 1.607. From the perspective of enterprise scale, the digital level of small- and

Table 1. Variable definitions

Variable Type	The Variable Name	Variable Symbol	Measure
Explained variable	Enterprise performance	*roa*	Return on total assets
		pro	Profit margin of operation
Explanatory variable	Digital Transformation level	*AP*	Production automation level
Intervening variable	Continuous innovation capability	*mrate*	R&D investment ratio
	The cost of sales	*cost*	Sales expense ratio
	The production efficiency	*productivity*	Productivity of labor
Control variable	The enterprise scale	*size*	The natural log of total assets
	Financial leverage	*lev*	Asset liability ratio
	The set up time	*time*	Current year - year of establishment
	If the export	*Isexport*	Exit = 1, Non-exit = 0

medium-sized enterprises is lower than that of large enterprises; the empirical results show that R&D high-tech enterprises have a higher level of digital cognition and greater digital investment, while the digital economy application ability of OEM enterprises needs to be improved. Finally, the application effect of large enterprises is more significant. The reason: large enterprises have obvious resource advantages such as human and material resources, usually as a core enterprise leading the industrial chain, bear the carrier of knowledge spillover, which to a certain extent, occupy the innovation resources of small- and medium-sized enterprises. From the enterprise establishment time length evaluation, it is found that the digital application degree of younger enterprises is higher than that of older enterprises; in terms of whether the product flow overseas, the degree of digitization of enterprises keen on overseas markets is higher than that of enterprises operating in the domestic market.

The essence of the digital transformation process is the process of business process informationization and business model innovation. This process involves deep learning, algorithm optimization, machine language, supply chain finance and blockchain knowledge, reflecting the importance of the learning ability of the executive team. Therefore, the cognitive level of the executive team, to a certain extent, determines the effect of enterprise digital intelligence transformation. Table 3 shows the cognition of middle and senior managers on the importance of the digital economy.

Among them, the digital transformation of the enterprise development strategy is critical to the proportion of entrepreneurs reached 72.84%, 18.53% entrepreneurs think it more important, think that the general or unimportant personnel accounted for less than 10%. As for whether to improve the core competence of enterprises, up to 74.14%

Table 2. Survey of Digital application

Enterprise	Business category	The number	Ratio of digitization	The digital economy	R&D enterprises	OEM enterprise
Type of equity	Private/foreign capital	160	74.59%	1. 765	1. 236	0.529
	state-owned	40	69. 32%	1. 312	0. 901	0.411
The enterprise scale	SMI	82	70. 21%	1. 698	1. 164	0.534
	Large Enterprise	115	76. 34%	1. 563	1. 137	0. 418
The set up time	5 years or less	22	86. 79%	1. 879	1. 312	0. 567
	5 ~ 10 years	45	77. 19%	1. 695	1.120	0.575
	10 ~ 15 years	56	71. 25%	1. 649	1. 267	0. 382
	More than 15 years	67	68. 69%	1. 458	0. 892	0. 566
Whether to export	Non-export	68	67. 53%	1. 672	1.146	0.526
	Exit	116	76. 78%	1. 734	1. 239	0. 495
Total	—	232	75. 64%	1.641	1.129	0.512

entrepreneurs affirmed its positive role; in the interview about whether it can significantly improve corporate performance, 64.66% entrepreneurs agreed with this view. Additionally, more than 40% managers believe that there is a lack of information technology support, followed by a lack of strategic support, lack of executive academic ability support, relevant policy support and cash flow support.

4.2 The Impact of Digital Transformation on Manufacturing Enterprise Performance

The digital transformation of manufacturing enterprises improves the responsiveness of the supply chain by optimizing business processes, shortening product lead time, thereby creating more delivered value for customers and gaining a competitive advantage.

The data of return on total assets in the first three columns of Table 4 shows that the *AP* variable is significantly positive at 1% probability, indicating that after the implementation of digital transformation, the performance of enterprises can be significantly improved through the synergy among enterprises. The values of *AP_1* and *AP_2* are more greater than 0, and the promotion effect is significant, indicating that both transformation paths can promote enterprise performance to a certain extent, and the positive effect of R&D manufacturing enterprises is stronger than that of general OEM manufacturing enterprises. Additionally, the larger the enterprise scale and the lower the debt ratio, the higher the performance; however, it is inversely proportional to its operating years. Therefore, table 4 shows that the hypothesis H1 holds. Digital transformation enables enterprises to realize the importance of continuous innovation; through digital

Table 3. Entrepreneurs' cognitive judgments on the digital economy

Cognition of the importance of digital transformation to the development of the company		The subjective judgment of whether to promote the competitiveness of enterprises		Subjective judgment of whether to improve corporate performance		Difficulties in digital transformation	
Very important	169(72.84%)	Yes	172(74.14%)	Yes	150(64.66%)	lack of Information technology Support	100(43.10%)
important	43(18.53%)	hard to judge	54(23.28%)	hard to judge	69(29.74%)	lack of financial support	46(19.83%)
generally	14(6.03%)	No	6(2.59%)	No	13(5.60%)	Lack of talent support	57(24.57%)
unimportant	6(2.59%)					lack of policy support	45(19.40%)
very unimportant	0(0.00%)					Lack of strategic and management support	69(29.74%)

Note: Scales are in parentheses

Table 4. Impact of digital transformation on enterprise performance

The dependent variable	roa			pro		
column	(1)	(2)	(3)	(4)	(5)	(6)
AP	0.068*** (0.010)			0.185*** (0.050)		
AP_1		0.062*** (0.014)			0.146** (0.069)	
AP_2			0.125*** (0.016)	0.322*** (0.079)		0.269*** (0.078)
size	0.088*** (0.016)	0.092*** (0.017)	0.090*** (0.015)	0.322*** (0.079)	0.317*** (0.084)	0.296*** (0.084)
lev	−0.316*** (0.048)	−0.329*** (0.043)	0.326*** (0.048)	−1.108*** (0.213)	−1.139*** (0.211)	−1.172*** (0.213)

(*continued*)

Table 4. (*continued*)

The dependent variable	roa			pro		
column	(1)	(2)	(3)	(4)	(5)	(6)
time	−0.016*** (0.002)	−0.015*** (0.002)	−0.014*** (0.002)	−0.049*** (0.012)	−0.043*** (0.015)	−0.043*** (0.012)
isexport	−0.029(0.016)	−0.027 (0.015)	−0.041* (0.017)	−0.131 (0.079)	−0.145 (0.093)	−0.153* (0.091)
Constant term	−1.625*** (0.348)	−1.733*** (0.359)	−1.492*** (0.336)	−5.561*** (1.642)	−5.786*** (1.649)	−5.188*** (1.657)
period	control	control	control	control	control	control
N	323	323	323	323	323	323

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, The brackets are standard errors, the same below

communities, self-media marketing and real-time customer communication, collaborative upstream and downstream enterprises design products to achieve the purpose of reducing transaction costs; the application of ERP system can greatly improve operational efficiency and enhance the core competence of enterprises. Therefore, hypotheses H2a, H2b, and H2c hold.

5 Conclusion and Suggestion

The digital economy has triggered changes in the industrial economic form, and it has become an inevitable trend for enterprises to innovate and develop by deeply empowering traditional enterprises to upgrade. However, combined with the analysis of many business practices, unicorn enterprises at the top of the pyramid have achieved a gorgeous turn through digital transformation, while many small- and medium-sized enterprises have fallen into transformation dilemma, and the transformation process is extremely difficult, which can be said to be a dilemma. Therefore, by investigating 232 manufacturing enterprises in the Pearl River Delta region, this paper analyzes the correlation mechanism between enterprise digital transformation and enterprise performance; and provides management enlightenment for the transformation and upgrading of manufacturing enterprises. To sum up, the digital transformation of enterprises is an inevitable trend. Every enterprise should be based on reality, From the top to ordinary employees, improve cognitive level, strengthen organizational learning, raise funds in many ways, and take a sustainable innovation as a concept.

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