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Can Customer Digital Transformation Facilitate Supplier Innovation Disclosure?

-- A Double Peer Effect Perspective

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Abstract: Digital transformation is an important starting point to drive the high-quality cultivation of new-quality productivity, while supply chain is the key conduction mechanism of digitally empowered enterprise innovation. This paper utilizes the supply chain data of A-share listed companies from 2012 to 2022 to explore the impact of digital transformation of customer enterprises on the disclosure of supplier enterprises' innovation information from the perspective of direct and indirect peer effects, and to explore ways to break through the dilemma of enterprise innovation information. The study reveals that: (1) customer digital transformation significantly improves the level of supplier innovation information disclosure, which helps to alleviate the supplier innovation information dilemma; (2) Mechanism analysis shows that the supply chain information relief effect is mainly transmitted along the supply chain through two channels: the "direct peer effect" of customers' innovation information disclosure and the "indirect peer effect" of suppliers' digital transformation; (3) The heterogeneity test shows that the supply chain information relief effect of digital transformation is more significant when there are overlapping investment institutions, geographic proximity and closer cooperation between customers and suppliers. This paper provides a new perspective for understanding the impact of digital transformation and supply chain participation, and provides policy insights for cracking the enterprise innovation information dilemma and then realizing innovation development.

Keywords: Digital transformation, Innovation disclosure, Information relief effect, Supply chain, Peer effect.

1. Introduction

Science and technology are the foundation of national strength, and innovation is the soul of national progress. The Third Plenary Session of the 20th CPC Central Committee listed "strengthening the status of enterprises as the mainstay of scientific and technological innovation" as an important part of "deepening the reform of the scientific and technological system", and proposed to build a scientific and technological financial system compatible with scientific and technological innovation, and to strengthen financial support for the major national scientific and technological tasks and scientific and technological small and medium-sized enterprises. It also proposes to build a financial system for science and technology in line with scientific and technological innovation, strengthen financial support for major national scientific and technological tasks and science and technology-based small and medium-sized enterprises (SMEs), and improve the support policy for long-term capital to be invested in early stage, small scale, long term, and hard technology. Innovation activities are usually characterized by long cycle, high risk and high uncertainty, and enterprises can't carry out innovation without the support of external funds, but external investors face the risks of incomplete disclosure of enterprise innovation information and difficulty in recognizing the authenticity of the information, which affects their willingness to invest [1]. At the same time, enterprise innovation information disclosure will produce strong repercussions in the capital market, product market and internal market of enterprises [2], and its high proprietary cost attributes often limit the disclosure choices of enterprises and lead to insufficient disclosure of innovation information, which leads to the innovation information dilemma between the enterprise and the external capital link [3, 4]. How to alleviate the innovation information dilemma, promote the acceleration of innovation resources to enterprises, and then help enterprises to continuously improve the ability of scientific and technological innovation is an important and urgent practical issue in the implementation of innovation-driven development strategy.

At present, the construction of digital China is accelerating, and digital transformation is becoming an important hand in cultivating new productivity and innovation-driven high-quality development. Recent studies have pointed out that enterprise digital transformation can significantly inhibit information disclosure violations [5] and improve the quality of information disclosure [6], and produce information "relief effect" [7], the role of information governance of enterprise digital transformation for innovation information dilemma provides a new important feasible direction.

Some studies have confirmed that the digital transformation of customer enterprises can effectively promote the innovation [8] and digital transformation [9] of supplier enterprises, improve the total factor productivity [10] of supplier enterprises, and realize the value co-creation among enterprises, but they have not yet touched on the important topic of whether there is a supply chain information relief effect of the digital transformation of customer enterprises, and the research on this issue can provide feasible paths for solving the innovation information dilemma of enterprises. The research on this issue can provide a feasible way to solve the enterprise innovation information dilemma. Therefore, it is of great significance to systematically analyze and empirically test whether and how the digital transformation of enterprises in the supply chain can alleviate the innovation information dilemma, in order to grasp the opportunities of digital technological change and make use of the supply chain transmission mechanism to strengthen the

governance of the innovation information dilemma of enterprises, to empower enterprise innovation, and to help achieve a high level of scientific and technological self-reliance and self-improvement.

Based on this, this paper uses the supply chain data samples of A-share listed companies from 2012 to 2022 to explore the impact of digital transformation of customer enterprises on the disclosure of suppliers' corporate innovation information under cross-firm relationships, and further discusses the mechanisms of “direct cohort effect” and “indirect cohort effect”, in order to provide a better understanding of the impact of digital transformation on suppliers' corporate innovation information disclosure. We further discuss the mechanisms of “direct cohort effect” and “indirect cohort effect” to expand the effective path for breaking the innovation information dilemma.

2. Mechanism Analysis and Hypothesis Formulation

2.1. The Impact of Digital Transformation of Customer Firms on Supplier Corporate Innovation Disclosure

Digital transformation through the depth of the application of digital technology, can realize the enterprise internal and external massive information deep mining, and non-standardized, unstructured data coding output for structured, standardized information, enhance the degree of information availability [11] and ensure the attribution of information, and then through the “information effect” to enhance the level of information disclosure. Social network theory. According to the social network theory, in the supply chain network relationship, upstream and downstream enterprise decision-making may imitate and learn from the decision-making or behavior of other enterprises in the same network [12], thus forming the cohort effect. Specifically, the customer enterprise innovation information disclosure has a positive effect of mitigating information asymmetry, attracting strategic alliances, mitigating agency conflicts and so on [12], which will lead to profound changes in the information environment faced by the supplier enterprise, in order to undertake the product change demand of the customer enterprise, to maintain the stability of the supply chain, and to enhance the value of the specialized assets, the supplier enterprise will take the initiative to enhance the level of innovation disclosure, and to form an information disclosure “Cohort effect”; the knowledge, experience, path and other information related to the digital transformation of customer enterprises will be spread along the supply chain, supplier enterprises based on their own interests, will follow the customer enterprises to carry out digital transformation, forming the ‘cohort effect’ of digital transformation. The “cohort effect” of digital transformation will be formed.

2.1.1. Direct Cohort Effect

The digital transformation of client enterprises can enhance their innovation information disclosure level through the “information effect”. On the one hand, from the perspective of information increment, as the degree of digital transformation continues to deepen, the ability of enterprises to use digital technology to mine data, obtain information, and process information has been rapidly improved, such as data acquisition, storage and analysis technology based on big data and cloud computing, which can transform massive information into standardized and structured information in a short period of time, and at the same time, the application of blockchain technology can realize the whole chain of enterprise data, ensuring information attribution and accuracy. tracking and verification, ensuring the attribution and accuracy of information. Based on this, enterprises rely on digital technology to build an information interaction platform, which can deliver incremental information on enterprise innovation activities to external stakeholders in real time and reduce the risk of adverse selection by external investors [13]. On the other hand, from the perspective of willingness to disclose information, digital transformation can influence management's disclosure decision by enhancing their perception of the costs and benefits of innovation information disclosure. The digital transformation of enterprises can promote the transformation of organizational form from vertical to flat organization, and information can be transmitted in real time between various departments, which strengthens internal collaboration. Under a good organizational system, management's opportunistic behavior and moral hazard are effectively restrained. On this basis, management disclosure of more innovative information can reduce the degree of information asymmetry with shareholders and external investors [14], and the benefits of information disclosure may be higher than the costs for management. Therefore, digital transformation can stimulate management's willingness and behavior to proactively disclose innovative information.

Innovation disclosure behavior of customer firms promotes innovation disclosure of supplier firms through the “cohort effect”. The theory of cohort effect originated from sociology points out that in order to pursue the legitimacy of behavior, individuals will be influenced by the choices of individuals of the same or similar status in their decision-making, i.e., “those who are close to Zhu are red” [14]. Vertical links between enterprises upstream and downstream of the same supply chain network can form a cohort network, in which there is not only information interaction and learning and imitation among enterprises, but also a spillover effect of behavioral effects through direct interest and business transactions [15]. First, innovation disclosure by customer enterprises will provide external information about their technological strength, business strategy and future development direction, including information related to market demand, product competitiveness and so on. Supplier enterprises may use this as the basis for their own production plans, R & D direction to adjust to better cooperate with the customer enterprise, but also a comprehensive assessment of their own external risks and the implementation of risk management measures, a good way is to share information with the supply chain upstream and downstream enterprises and the establishment of a collaborative mechanism to jointly deal with [16], which also requires supplier enterprises to disclose more innovation information. Second, in order to establish and maintain good relationships with customers and keep long-term cooperation with them, supplier firms invest in relationship-specific assets as a commitment to express their confidence in cooperation with customer firms to maintain a stable and trustful relationship. These relationship-specific assets are used to produce products or services uniquely designated by the customer, due to the short-term difficult to move to other uses and has a strong irreversibility, so the supplier company will take the initiative to receive and pay attention to the customer's corporate development strategy, competitive

strategy and product technology requirements and other information, and actively respond to customer needs to carry out changes. At the same time, in order to maintain the trust and cooperation between the two sides, release their own and customer technology synchronization and innovation of positive signals, supplier enterprises will choose to disclose more innovation information; Finally, the customer disclosure of innovation information will produce information spillover effect. Through the economic linkage and business transactions between enterprises in the supply chain network, supplier enterprises can obtain relevant production, technology and investment information of customer enterprises, perceive the future development trend of the industrial chain [17], and thus adjust their business decisions. For example, in order to reduce business risks, maintain the stability of the supply chain and the competitive position of the enterprise, the supplier enterprise will be proactive and timely layout of technological innovation, increase investment in research and development, etc. In this case, supplier companies will voluntarily disclose more innovation information in order to obtain investors' attention and policy support to reduce the degree of information asymmetry with the outside world.

2.1.2. Indirect Cohort Effect

The digital transformation of the customer's enterprise is facilitated by the supply chain "cohort effect" of the supplier's enterprise digital transformation. From the customer's perspective, suppliers are deeply embedded in their interests, and the behavior of customers will have a significant impact on suppliers. On the one hand, customer enterprises will provide support to help suppliers carry out digital practices based on self-interest [18]. Through digital transformation, customer enterprises can strengthen the connection and communication with suppliers in terms of business practices to realize efficient supply chain interconnection. However, when the digitalization level of suppliers differs greatly from that of customers, i.e., there is a "digital divide", the effectiveness of customer digital transformation empowerment will be significantly reduced [8]. In order to improve the operational efficiency of the supply chain and fully release the effectiveness of digital transformation, customers may take the initiative to help suppliers to carry out digital transformation, such as sending digital technicians to suppliers and providing digital transformation related experience [2], thus improving the efficiency of suppliers' digital transformation. On the other hand, changes in customer demand will force suppliers to adopt flexible response strategies. Consumers' green awareness, diversified needs, and increased demand for product technology have led to changes in customer companies' production. Through the use of digital technology, customers are able to process consumer market information efficiently and form a standardized and practical demand for change, which includes changes in the demand for intermediate goods provided by suppliers and increased monitoring of supplier innovation [19]. In response to customer demand, suppliers will implement digital transformation at the production level; in addition, the digital transformation of customer enterprises will increase the demand for real-time and accurate transaction data, which will force supplier enterprises to pay attention to the generation, storage and flow of data elements. Therefore, the demand feedback can form the driving force of customer digital transformation on supplier enterprises' digital transformation.

From the supplier enterprise's point of view, it needs to continuously improve the resource allocation efficiency and collaborative processing ability, and enhance the dynamic ability to adapt to the external market environment [8]. On the one hand, customer digital transformation can form the information spillover effect, providing suppliers with ways to imitate and learn. Customer digital transformation can broaden the access to information and knowledge [20], increase the connectivity and richness of the information network, so that suppliers can access the interactive, shared data and information provided by the customer [21], to provide efficient learning and communication channels for suppliers, to promote the digital transformation of information in the supply chain collaborative network within the spillover, which will help suppliers to obtain more digital knowledge. Top managers will actively imitate and learn from customers' digital transformation strategy practices when making relevant decisions. On the other hand, competitive pressure among supply chains is also an important source of digital transformation cohort effect. There may be a non-equal interest exchange relationship between supply chain enterprises, at this time there is a certain degree of extrusion relationship between the vertical industry chain subjects, this extrusion relationship is reflected in the hidden information seeking opportunistic behavior. Digital transformation amplifies customers' advantages in terms of rights, resources, or status, and in order to quickly adapt to customers' demands for efficiency and collaboration, and to alleviate competitive pressures within the supply chain, suppliers will choose a digitalization strategy that is aligned with their customers. In addition, supply chain linkage is a "survival of the fittest" in the process of continuously satisfying customers' dynamic demands. The application of digital technology by the customer allows the aggregation and integration of a huge amount of information about suppliers and companies in the same industry, which will bring great uncertainty to the original cooperative relationship. In order to prevent competitors from encroaching on the market and stabilize supply chain customer relationships, suppliers will actively engage in digital transformation activities.

Consistent with the preceding analysis, the implementation of digital transformation by supplier firms will lead to the disclosure of their own innovation information through the "information effect".

Combining the above analyses, this paper puts forward the hypothesis that the digital transformation of customer enterprises will promote the disclosure of supplier enterprises' innovation information.

3. Data and research design

3.1. Sample Selection

Drawing on the study of Qingyuan Li et al, this paper selects the top five customer relationship data of A-share listed companies in Shanghai and Shenzhen from 2012 to 2022 as the research sample, and retains the observation samples in which both suppliers and customers are listed companies. After processing, 2579 supplier-customer year observations are finally obtained.

3.2. Variables and Models

3.2.1. Definition and measurement of key variables

Explained variable: corporate innovation disclosure (Inno_Disc). In this paper, we refer to the practice of Zhou et

al [4], and adopt the word frequency analysis method of seed word set + Word2vec similar word expansion to measure the level of supplier innovation disclosure. The word frequency of technological innovation vocabulary was obtained by summarizing the natural language processing and text analysis of the WinGo financial text data platform, and the proportion of the calculated keyword word frequency in the text of the enterprise's annual report was multiplied by 1,000, and the magnitude of the value reflected the richness of the enterprise's disclosure of innovation information.

Explanatory variable: the degree of digital transformation of client companies (Cus_digital). This paper adopts the digital transformation data of listed companies provided by CSMAR, which helps to comprehensively measure the level of digital transformation of enterprises.

3.2.2. Research model

In order to investigate the impact of customers' digital transformation on suppliers' corporate innovation disclosure, the article constructs the following model:

$$Inno\_Disc_{i,t} = \alpha + \beta Cus\_digital_{i,t-1} + \sum Controls$$

Where Inno_Disc is the level of innovation disclosure of supplier firms in the ith supply chain at year t; Cus_digital is the digital transformation of customer firms at year t-1; Controls denotes the micro characteristics of supplier firms; this paper focuses on the coefficient β of the coefficient Cus_digital, and if β is significantly positive, it suggests that the customer's digital transformation can facilitate the supplier firms' innovation disclosure, which in turn supports the hypothesis.

4. Empirical Results

Table 1 reports the regression results of the effect of digital transformation of customer firms on the level of innovation disclosure of supplier firms. Specifically, column (1) is regressed using only the digital transformation of customer enterprises on supplier enterprises' innovation information disclosure, and the results show that the regression coefficient is 0.0794 and is significant at the 1% level, which indicates that the higher the degree of digital transformation of the customer enterprises, the supplier enterprises tend to externally disclose more innovation information. Columns (2)-(4) are regressed based on column (1) by adding enterprise-related control variables in turn, and the customer enterprise digital transformation index (Cus_digital) is still significant. The hypotheses of the article are verified, in which each unit increase in the digital transformation of customer firms increases the level of innovation disclosure of supplier firms by 0.0351 units.

Table 1. The Impact of Customer Digital Transformation on Supplier Corporate Innovation Disclosure

	(1)	(2)	(3)	(4)
Variables	Inno_disc	Inno_disc	Inno_disc	Inno_disc
Cus_digital	0.0794***	0.0722***	0.0698***	0.0351***
	(10.2052)	(10.0770)	(9.6199)	(4.3315)
Size		-0.5051***	-0.4161***	-0.1647**
		(-8.4798)	(-5.6444)	(-2.3381)
Lev		-3.7379***	-3.7446***	-3.5254***
		(-9.2433)	(-9.1274)	(-8.7075)
Roa		-2.9687***	-2.9171***	-3.2290***
		(-4.9011)	(-4.6485)	(-4.9289)
Age		-2.4776***	-2.5149***	-1.8989***
		(-10.2643)	(-10.2867)	(-7.4294)
Cashflow		1.2454	1.6413	2.7792***
		(1.1401)	(1.5041)	(2.6779)
TobinQ		-0.0123***	-0.0111***	-0.0104***
		(-5.2804)	(-5.2913)	(-6.6212)
Board			0.2888	1.0361**
			(0.5674)	(2.0260)
Indboard			0.0236	0.0318**
			(1.5426)	(2.0594)
Top1			-0.0021	0.0174***
			(-0.3107)	(2.7773)
Institution			-0.0102**	-0.0062
			(-2.2716)	(-1.4526)
_cons	5.5029***	25.7553***	22.9588***	14.0915***
	(18.5287)	(19.1742)	(12.2162)	(6.3120)
Industry/Year	No	No	No	Yes
N	2579	2579	2579	2579
Adj. R^2	0.0410	0.1901	0.1927	0.3250

To eliminate other omitted variables and factors that create endogeneity between the core variables, for example, market structural pressures can have a simultaneous effect on the digital transformation of customer firms and the disclosure of supplier firms' innovations, which can bias the estimation of causality. Therefore the article eliminates the endogeneity

effect through instrumental variables.

The first one is to borrow the research treatment of Lewbel [22] and use the third power of the difference between the difference between the customer digital transformation index and the mean value of the digital transformation index by industry secondary code and province as an instrumental variable (Lewbel IV); and the second one is to use the mean value of the same province and the same industry in the same year, except for the customer firms, as an instrumental variable (Digital_IV). Firstly, the positive correlation test of instrumental variables on explanatory variables, the results are shown in column (1) and column (2) of Table 2, the regression coefficients are significantly positive, 0.0048 and 0.8767, respectively, and the F-statistics are greater than 10, which excludes the possibility of weak instrumental variables. Second, the results of the exclusion constraint test of instrumental variables as shown in Table 2 columns (3) and (4) show that the instrumental variables are not significant for the level of disclosure of innovation information of suppliers' firms of the explanatory variables, which is in line with the exclusion requirement. Finally, the coefficients of customer digital transformation as shown in the results of Column (5) and Column (6) are 0.0342 and 0.0458, respectively, which are both significantly positive at the 1% level, which is more in line with the results of the benchmark regression, suggesting that the results of the positive facilitation of the digital transformation of the customer firms on the level of supplier firms' disclosure of innovation information are robust.

Table 2. Instrumental variable test results

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Cus_digital	Cus_digital	Inno_disc	Inno_disc	Inno_disc	Inno_disc
Lewbel IV	0.0048***		-0.000			
	(46.0)		(-0.11)			
Digital_IV		0.8767***		0.0133		
		(24.7)		(0.85)		
Cus_digital			0.0360***	0.0305***	0.0342***	0.0458***
			(3.17)	(3.11)	(3.04)	(2.90)
_cons	36.1375***	8.0728	14.0616***	13.9357***	14.1256***	13.8128***
	(7.87)	(1.46)	(6.24)	(5.86)	(6.32)	(5.79)
Ctrs	Yes	Yes	Yes	Yes	Yes	Yes
N	2579	2215	2579	2215	2579	2215
Adj. R^2	0.6073	0.4826	0.3248	0.3414	0.3250	0.3409

Table 3. Mechanism of action tests

	(1)	(2)	(3)	(4)
variable	Cus_inno_disc	Inno_disc	Digital	Inno_disc
Cus_digital	0.099***	0.029***	0.168***	0.0177**
	(11.8320)	(3.5739)	(9.9095)	(2.2345)
Cus_inno_disc		0.0421*		
		(1.8812)		
Digital				0.103***
				(10.6004)
_cons	7.503***	15.04***	-1.4182	14.22***
	(3.1561)	(6.2869)	(-0.3276)	(6.6103)
Solel Z		1.983**		7.82***
Ctrs	Yes	Yes	Yes	Yes
N	2532	2532	2579	2579
Adj. R^2	0.1836	0.3481	0.4202	0.3554

Digital transformation of customer enterprises and innovation disclosure level of supplier enterprises: First, the direct cohort effect in supply chain network, i.e., the digital transformation of customer enterprises will increase the willingness to disclose innovation information, and improve their own innovation disclosure level (Cus_inno_disc), and then increase the innovation disclosure level of supplier enterprises through the “direct cohort effect” in the supply chain network. Then through the “direct cohort effect” in the supply chain network, it will enhance the level of innovation information disclosure of supplier enterprises. The second is the indirect cohort effect in the supply chain network, i.e., the digital transformation of customer enterprises first promotes the digital transformation of supplier enterprises through the “indirect cohort effect”, and then enhances the level of innovation information disclosure of supplier enterprises. Like the measurement of independent variables and dependent variables, the level of innovation disclosure of customer companies and the degree of digital transformation of supplier companies can be obtained. The results of the cohort effect mediation mechanism test are reported as shown in Table 3. The Cus_digital coefficient in column (1) is significantly positive at the 1% level, indicating that customer digital transformation helps to improve the level of innovation disclosure of the firm itself. Both Cus_digital and Cus_inno_disc coefficients in column (2) are significantly positive, and the Cus_digital coefficient is slightly smaller than that of the benchmark regression in Table 3, which indicates the existence of partial mediation effect, and also the Sobel test supports the existence of mediation effect; similarly, the Cus_digital coefficient in column (3) is significantly positive at 1% level, which suggests that customer digital transformation can promote the digital transformation of supplier firms. The coefficients of Cus_digital and Digital in column (4) are both significantly positive, and the coefficient of Cus_digital is slightly smaller than that of the benchmark

regression in Table 1, which indicates that there is also a part of the mediation effect, and the Sobel test also supports the existence of the mediation effect.

5. Conclusion

Based on the supply chain network relationship, this paper empirically analyzes and tests the relief effect of digital transformation of customer enterprises on supplier enterprises' innovation information disclosure, using supply chain enterprises listed on A-share stock companies from 2012 to 2022 as samples. It is found that: (1) digital transformation of customer firms significantly promotes the improvement of supplier firms' innovation information disclosure level and helps to alleviate supplier firms' innovation information dilemma, which is valid in a series of endogeneity tests and robustness tests such as instrumental variable method, replacing the measurement method of explanatory variables and changing the regression model. (2) The information relief effect arises mainly through two mechanisms of action. First, the direct cohort effect, i.e., customers' digital transformation will enhance their own innovation information disclosure level through the information effect, which will then be transmitted along the supply chain through the cohort effect, thus promoting suppliers' enterprises to disclose more innovation information. The second is the indirect cohort effect, i.e., customers' digital transformation will promote suppliers' digital transformation through the cohort effect, which will enhance suppliers' innovation information disclosure level through the information effect. (3) Heterogeneity test results show that the supply chain information relief effect of digital transformation varies significantly across supply chain relationships. Specifically, the promotion effect of customer digital transformation on supplier innovation information disclosure level is more significant when there are supply chain overlapping investment institution shareholding of the customer and supplier, the physical office of the customer and supplier is in the same province and the closer the supply chain cooperation relationship, i.e., the higher degree of importance of the customer.

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