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The Spillover Effect of Customer Digital Transformation on Enterprise Value Co-creation:Micro Evidence From The Enterprise Efficiency Perspective

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Abstract

As the phenomenon of digital spillover at the macro-economic level gains prominence, the impact of digital spillover generated by enterprise digital transformation at the micro-economic level is also amplified. Using the top five customer data sets of Chinese A-share listed enterprises from 2007 to 2021, this research explores the potential for customer digital spillover to foster enterprise value co-creation in supply chain, i.e., whether customer digital transformation can increase enterprise value. The benchmark tests document customer digital spillover is positively associated with enterprise value co-creation in the supply chain, and this finding holds to a battery of robustness tests. Moreover, channel tests from the perspective of enterprise efficiency indicate that customer digital spillover impacts enterprise value co-creation in the supply chain through the improvement of enterprise production efficiency, enterprise innovation efficiency, and enterprise investment efficiency. Finally, the heterogeneity tests reveal that the effect of customer digital spillover on value co-creation among enterprises is more pronounced for enterprises with the wider digital gap, the more trade credit supply, the higher financial constraints and the greater dedicated assets. Overall, this research extends prior literature on the real effects of customer digital transformation and the influencing factors of value co-creation, providing references for exploring the interactive logic among enterprises in the supply chain.

Keywords: Enterprise Value; Digital Transformation; Production Efficiency; Innovation Efficiency; Investment Efficiency; The Supply Chain

1. Introduction

The impact of digital spillover exceeds that of digitalization alone, as evidenced by the joint Oxford Economics and Huawei report "Digital Spillover-measures the True Impact of the Digital Economy", which highlights the need for more research in both academic and practical circles. In actuality, there are several typical instances of publicly traded enterprises like Intel and General Aircraft reconstructing the supply chain business model, strengthening ecological partners' collaboration, and enhancing the industrial chain's operational efficiency. This creates the conditions for the emergence of the value co-creation production mode, driven by the digital revolution and marked by strategic subversion. Accelerating the development of an efficient mechanism for supply chain value creation is a necessary way to drive the industrial chain towards high-end modernization, especially given the prevalence of adverse factors like the impact of trade protectionism and economic downward pressure. Among them, actively exploring the enabling role of enterprise digital transformation is the fundamental driving force to improve the symbiotic development ecology and value upgrading of the supply chain.

Generally speaking, the vertical economic connection between customers and enterprises in the commodity market based on the supply chain not only facilitates the flow of factors and resource flow between upstream and downstream enterprises, but also promotes the formation of an interest correlation mechanism of sharing weal and woe among enterprises. Therefore, as an innovative and natural economic connection, the bridge role of supply chain is believed to be an important and reasonable research situation for the potential economic impact of customers and micro economic channel for the spillover effect, according to Cohen and Frazzini (2008). Given this, using the top five customer data sets of Chinese A-share listed enterprises from 2007 to 2021, this research explores the potential for customer digital spillover to foster enterprise value co-creation in the supply chain, i.e., whether customer digital transformation can increase enterprise value.

This research hypothesizes that customer digital transformation supports enterprises in the supply chain in developing a multi-factor-driven value co-creation system as well as forming a cooperative strategic partnership with complementary benefits and risk sharing (Van and Van, 2011) because of the strong synergy and permeability of digital technology adopted in customer digital transformation (Majchrzak, 2016), which helps enterprises achieve efficiency and kinetic energy conversion (Li and Choi, 2009). Therefore, customer digital transformation improves enterprise value by the circulation and sharing of information resources and the enhancement of cooperation and trust relationship (Marrone et al., 2007; Novikov and Sazonov, 2020), that is, customer digital spillover realizes value co-creation. Next, this research examines at least three potential channels that customer digital transformation can significantly affect enterprise value. Firstly, customer digital transformation drives enterprise production efficiency to improve enterprise value by realizing the professional division of labor among enterprises and improving the input-output ratio of the production means (Li et al., 2021; Reiman et al., 2021). Secondly, customer digital transformation drives enterprise innovation efficiency to improve enterprise value by realizing the joint innovation among enterprises and boosting the independent innovation ability of enterprises (Schneider and Kokshagina, 2021; Li et al., 2023). Thirdly, customer digital

transformation drives enterprise investment efficiency to improve enterprise value by alleviating the synergistic contradiction between supply and demand information and helping enterprises to capture investment opportunities(Taylor and Xiao, 2010; Hofmann, 2017; Eller et al., 2020). Thus, along the supply chain, customer digital spillover resulting from customer digital transformation will foster enterprise value co-creation.Furthermore, considering that the spillover effect of customer digital transformation on enterprise value depends on the strength of the customer digital spillover effect, this research hypothesizes that the positive spillover effect is more prominent when enterprises have a wider digital gap, the more trade credit supply, the higher financial constraints, and the greater dedicated assets because a higher marginal contribution from the digital spillover caused by customer digital transformation to the improvement of enterprise value in the above situations.

The main contributions include the following aspects: Firstly, the literature on the economic consequences of customer digital spillover resulting from digital transformation in the supply chain is particularly enriched. Recent studies have innovatively examined the impact of customer digital transformation on enterprise innovation behavior (Yang et al., 2022) and enterprise digital transformation behavior (Guo et al., 2023), which examined the interactive relationship between digitalization and innovation among enterprises in the supply chain. This research deeply dissects that the spillover of customer digital transformation, a mostly random spontaneous event independent of market mechanisms, affects enterprise value from the micro level, which effectively identifies the external characteristics of digital spillover and enhances all circles' understanding of the supply chain digital spillover.

Secondly, the associated research on the influencing aspects of value co-creation is expanded. Previous research has already been conducted to examine whether or how to accomplish value co-creation between enterprises from the viewpoints of digital ecosystems (Zaki et al., 2017), digital servitization (Sjödin et al., 2021), and digital platforms (Jovanovic et al., 2022). The achievement of value co-creation through digital spillover brought about by customer digital transformation, however, has not been the subject of any literature. Furthermore, in terms of research methodology, the majority of the investigation currently on value co-creation is mostly focused on exploring the development mechanisms of traditional commercial enterprises through theoretical research (Sheth, 2019), model construction (Ranjan and Read, 2016), or case analysis (Matarazzo et al., 2021), lacking a relatively rigorous empirical test involving a sizable sample to mine the influencing factors of value co-creation and empirically examining whether value co-creation is occurring in the digital context (Hamidi and Machold, 2020). As a result, this research employs large sample data to statistically assess the value co-creation impacting elements, providing convincing micro-empirical evidence of value co-creation and serving as a reference for subsequent research on value co-creation.

Thirdly, there is an expansion of the research on the logic of interaction among supply chain enterprises. As of right now, most studies on the interactive logic in the supply chain between enterprises mostly concentrate on figuring out how resource sharing and competitive pressure influence enterprise behavior (Yan et al., 2025; Guo et al., 2023). Nevertheless, this research demonstrates customer digital spillover can bring economic consequences to enterprises by

affecting enterprise efficiency which based on production relationship, innovation relationship and investment relationship of the supply chain, thus providing an more clear understanding of the micro-interaction channels between upstream and downstream enterprises and displaying suggestions for the subsequent interaction between enterprises through empirical evidence based on the idea of an endogenous supply chain.

2. Literature Review

This research is related to two streams of literature. The first stream of literature focusing on the economic consequences of customer digital spillover that has been an initial stream of writing Lately. At present, the majority of the literature examines the reasons for and effects of enterprise digital transformation, that is, how digital transformation affects enterprises to restructure their business models and production processes (Fitzgerald et al., 2014; Vial, 2021). Only a small amount of literature focuses on the spillover effects on related enterprises caused by the large number of data elements created and accumulated by enterprise digital transformation (Xiao, 2020). For example, digital spillover can lead to the improvement of enterprise innovation levels (Yan et al., 2025) and the realization of enterprise digital transformation when enterprises are in a supply chain ecosystem (Guo et al., 2023).However, a review of the existing literature reveals that different expressions, such as the spillover effect of enterprise digital transformation, the contagion effect of enterprise digital transformation, or the industrial linkage effect of enterprise digital transformation, are used by academic circles, and digital spillover is not included as a professional term in academic papers.Therefore, as an important extension of the theme of enterprise digital transformation, the connotation, characteristics and theoretical framework of digital spillover should be clarified.

In this research, digital spillover, known as a digital externality, refers to the potential unconscious benefits and harms that the digital activities of macro- and microeconomic individuals bring to other individuals or the whole society without costing the beneficiaries or the producers. Firstly, digitalization activities are the obvious place to start for digital spillover. Digitalization refers to the process of economic individuals using digital technology to arrange and combine the data of perceptual object existence and object activity encoded as 0 and 1 (Parviainen et al., 2017). This coding process reintegrates existing resources at the organizational level into the basic elements that can be created, stored, and transported: data. Digitalization activities thus become the logical starting point for digital spillovers. Secondly, data is the fundamental component of digital spillover. Data, as a distinctive commodity, has unique traits such as non-competitiveness and incomplete exclusivity (Huang, 2022). The non-competitiveness of data indicates that the use of data by one individual does not affect the use of data by other individuals; that is, data can be duplicated and shared by different individuals at the same time without intangible or value loss(Saarikko et al., 2022). Incomplete exclusivity means that the data cannot be exclusively owned by one individual; that is, it is impossible to completely exclude other individuals from the data consumption process and completely prevent them from enjoying the data's value. Therefore, the nature of some public goods of data makes it easy to spillover the endogenous interaction process of data among individuals in different economies, giving birth to

digital spillover. Thirdly, the essence of digital spillover is the externality of digitalization activities. The externality of digital spillover requires two conditions to be met: digital spillover is independent of the market mechanism, and digital spillover is produced unintentionally and involuntarily and affects the welfare of other individuals or the whole society. Fourth, the basic components of digital spillover include spillover source, spillover host, spillover channel, spillover performance, and spillover factor. The source of digital spillover refers to the economic individual that takes part in digitalization activities; the host of digital spillover refers to the receiver of the digitalization activities of the economic individual; the spillover channel of digital spillover refers to the connection form with network characteristics and permeability, which mainly includes agglomeration, industry, and supply chain; the manifestations of digital spillover include external economies and external diseconomies ; and the factor of digital spillover is the inducing condition of digital spillover, which mainly includes the demonstration and imitation effect, competition effect, connection effect, and human capital flow effect. Fifth, relational deterioration and dynamic spillover are characteristics of digital spillover. Because of relationship deterioration, digital spillover is determined by the degree of correlation and interaction between economic individuals. That is, as the degree of correlation and interaction between economic individuals decreases, so will the radiation range and impact of digital spillover. The dynamic spillover implies that enterprises' characteristics, the amplitude and breadth of the data flow, and the smoothness of the spillover channel all influence digital spillover.

The second stream of literature focuses on the research of value co-creation among enterprises. The existing studies have carried out detailed theoretical discussions on how to achieve value co-creation among enterprises from the perspectives of resource complementary (Agrawal and Rahman, 2015), capability integration (Williams and Aitken, 2011), and value process (Corsaro, 2019), but there is no literature on whether and how to achieve value co-creation of digital spillover caused by digital transformation of customers. The mainstream view is that the essence of value co-creation is to change the positioning of customer value destroyers, let them directly participate in the production process of enterprises as value producers, and help empower enterprises to determine the production through value expression and value transmission, and finally realize the enterprise value creation and realization. Also, research shows that in the era of the digital economy, the evolution of enterprise value creation pathed from separate value creation to common production to create value change. Enterprise value creation logic also realized commodity dominant logic (Normann and Ramirez, 1993), customer dominant logic (Prahalad and Ramaswamy, 2000), and service dominant logic conversion (Vargo and Lusch, 2004). Customer-led logic is mainly based on the dual interaction between customers and enterprises, paying attention to the original value that customers bring to enterprises (Heinonen et al., 2010); service-led logic is mainly based on the multiple relationships of multiple participants creating value and analyzing the improvement effect of multiple participants participating in the enterprise value from the perspective of the network system (Pinho et al., 2014). However, regardless of the perspective or logic, value co-creation focuses on the interaction process between the enterprise and stakeholders (Gronroos and Voima, 2013). In addition, the existing topics of value co-creation mostly focus on using theoretical research, model construction, or case analysis to explore the value co-creation mechanisms of traditional commercial enterprises

(Matarazzo et al., 2021), with a lack of relatively rigorous large sample empirical tests. It is necessary to explore the influencing factors of value co-creation and clarify the relationship between customer digital transformation and value co-creation to lay a solid theoretical foundation for micro-digital spillover to drive the symbiotic development of the supply chain.

3. Research Hypothesis

3.1. The Spillover Effect of Customer Digital Transformation on Enterprise Value

Customer digital transformation supports enterprises in the supply chain in developing a multi-factor-driven value co-creation system as well as forming a cooperative strategic partnership with complementary benefits and risk sharing (Van and Van ,2011). The reason for this is that the integration of digital technology adopted in customer digital transformation has strong synergy and permeability (Majchrzak, 2016), and digital, informational, and innovative elements fundamentally affect an enterprise's production, innovation, investment, and other business processes, which helps enterprises achieve efficiency and kinetic energy conversion (Li and Choi, 2009).

On the one hand, customer digital transformation not only promotes the circulation and sharing of information resources (Cubillas et al., 2024) and changes the pattern and method, saving the traditional marketing human from collecting customer information (Popkova et al., 2022), but also helps enterprises obtain accurate market information (Endres et al., 2024) and analyze and predict customer response to products (Novikov and Sazonov, 2020), improving the effectiveness of marketing. At this time, customer digital transformation improves enterprise value; that is, customer digital spillover realizes value co-creation.

On the other hand, customer digital transformation not only builds a strong trust relationship with customer stakeholders and improves cooperative stability (Marrone et al., 2007), significantly reducing the enterprise transaction costs caused by the uncertainty of the market environment (Vargo and Lusch, 2016), but also provides enterprises with more market opportunities and market channels due to long-term partnerships (Wynstra et al., 2015), boosting enterprises to well integrate production factors (Barrett et al., 2015) and realize scale economies (Hortacsu and Syverson, 2015). At this time, customer digital transformation improves enterprise value; that is, customer digital spillover realizes value co-creation.

In summary, the second hypothesis H1 is proposed:

H1: Customer digital transformation improves enterprise value, that is, customer digital spillover realizes value co-creation.

3.2. The Channels of Customer Digital Transformation Affecting Enterprise Value

This research believes that there are three main channels which based on production relationship, innovation relationship and investment relationship of the supply chain.

The first is the enterprise production efficiency channel based on production relationship of the supply chian. In other words, customer digital transformation improves enterprise value by

driving enterprise production efficiency. On the one hand, customer digital transformation utilizes digital technology to dramatically speed up information dissemination and improve communication efficiency between upstream and downstream enterprises in the supply chain (Setia et al.,2013; Li et al., 2021), which facilitates the development of labour professional division production mode (Howard et al., 2007) by resource integration and connection modularization among enterprises (Xue et al., 2013). Labour professional division gives full play to the comparative advantages of various production factors, promoting the growth of enterprises production efficiency (Bai et al., 1997), which helps enterprises to realize value creation. On the other hand, customer digital transformation promoting supply chain data connectivity is beneficial for enterprises to repair their operation process, modify their production schedule, and optimize production allocation from production control, material scheduling, energy control, and other aspects through dynamic management and intelligent analysis (Zhou et al., 2021). In this situation, enterprises achieve more output with less input of production resources and factors by lowering the production cost, improving production flexibility and increasing production efficiency, which helps enterprises generate more value (Reiman et al., 2021).

The second is the enterprise innovation efficiency channel based on innovation relationship of the supply chian. In other words, customer digital transformation improves enterprise value by driving enterprise innovation efficiency. On the one hand, customer digital transformation has narrowed the distance between enterprises and customers because of the twin and cross-time nature of digitalization (Lanzolla et al., 2021), providing enterprises with a timely understanding of the customers' demand data, usage, opinions, and suggestions (Liu et al., 2023), as well as precisely predicting customers' consumption tendencies (Steiber et al., 2021), which has become an important source for enterprises to carry out targeted independent innovation(Schneider and Kokshagina, 2021). Not only do product development and design boost innovation efficiency, but the enterprise's technological upgrades and improvements also do so (Li et al., 2023). These factors provide a solid basis for the continuous improvement of enterprise value. On the other hand, customer digital transformation fosters networked joint innovation among enterprises by offering a data and knowledge-sharing platform for enterprises to obtain cutting-edge digital technologies (Geng et al., 2025), and expedite the exchange of innovation resources and technical knowledge among enterprises (Condea et al., 2017). Joint innovation strengthens innovation collaboration (Forman and Zeebroeck, 2012) while also bolstering innovation efficiency between enterprises (Abdalla et al., 2021). The efficient yields of enterprise innovation are transformed into economic benefits which boosts enterprise value (Bresciani et al., 2021).

The third is the enterprise investment efficiency channel based on investment relationship of the supply chian. In other words, customer digital transformation improves enterprise value by driving enterprise investment efficiency. On the one hand, customer digital transformation broadens the enterprise information access channels and enhances the enterprise information source, assisting enterprises in promptly obtaining market demand and market trends (Xu et al., 2023), as well as coordinating enterprise investment activities based on customer orders and forecast data (Taylor and Xiao, 2010). As a result, lowering the level of information asymmetry

across enterprises successfully resolves the supply and demand collaboration paradox (Lee et al., 1997; Hofmann, 2017), increasing enterprise investment efficiency. Under this circumstances, the improvement of enterprise investment efficiency contributes to the preservation of a favourable operating environment and increases enterprise value (Raman and Shahrur, 2008). On the other hand, customer digital transformation deepens the breadth and depth of enterprise information (Cachon and Lariviere, 2001), which benefits enterprises in accurately understanding changes in customer operations (Özer et al., 2011), identifying profitable investment opportunities, and projecting future returns on investment (Lee et al., 1997). In this situation, the best investment plan and the right investment choice enhance the enterprise investment decision's quality (Eller et al., 2020), which in turn results in an increase in enterprise value through increased enterprise investment efficiency.

In summary, the second hypothesis H2 is proposed:

H2a: Customer digital transformation improves enterprise value by driving enterprise production efficiency.

H2b: Customer digital transformation improves enterprise value by driving enterprise innovation efficiency.

H2c: Customer digital transformation improves enterprise value by driving enterprise investment efficiency.

3.3. The Heterogeneity of Customer Digital Transformation Affecting Enterprise Value

The spillover effect of customer digital transformation on enterprise value depends on the strength of the customer digital spillover effect. This research considers the difference in benchmark results from four different perspectives of the digital gaps between customers and enterprises: enterprise trade credit supply, enterprise financing constraints, and enterprise dedicated assets.

Firstly, the wider digital gap between customers and enterprises results in a higher marginal contribution from the digital spillover caused by customer digital transformation to the improvement of enterprise value, which means that the spillover effect of customer digital transformation on the enterprise value is more obvious.

Secondly,the more trade credit supply between customers and enterprises results in the closer relationship and the more frequent communication among enterprises,which is a higher marginal contribution from the digital spillover caused by customer digital transformation to the improvement of enterprise value, making the spillover effect of customer digital transformation on the enterprise value is more evident.

Thirdly, the higher financial constraints of enterprises indicate that the difficulty of the enterprise transformation makes enterprises have a stronger willingness to actively capture and employ the resource advantages from the digital spillover caused by customer digital transformation, resulting in a higher marginal contribution from the digital spillover to the improvement of enterprise value. Therefore, the value co-creation effect of customer digital spillover is stronger when enterprise financing constraints are greater.

Fourth, the greater dedicated assets of enterprises represent the deeper binding relationship between enterprises and customers, which results in a higher marginal contribution from the digital spillover caused by customer digital transformation to the improvement of enterprise value, indicating that the impact of customer digital transformation on enterprise value is more prominent.

In summary, the second hypothesis H3 is proposed:

H3a: The effect of Customer digital transformation on enterprise value is more pronounced for enterprises with the wider digital gap.

H3b: The effect of Customer digital transformation on enterprise value is more pronounced for enterprises with the more trade credit supply.

H3c: The effect of Customer digital transformation on enterprise value is more pronounced for enterprises with the higher financial constraints.

H3d: The effect of Customer digital transformation on enterprise value is more pronounced for enterprises with the greater dedicated assets.

Figure 1 shows the research idea diagram for this research. It can be seen that customer digital transformation maybe effect enterprise value because of the improvement of enterprise production efficiency, enterprise innovation efficiency and enterprise investment efficiency.And the above effect may be more pronounced for enterprises with the wider digital gap, the more trade credit supply, the higher financial constraints and the greater dedicated assets.

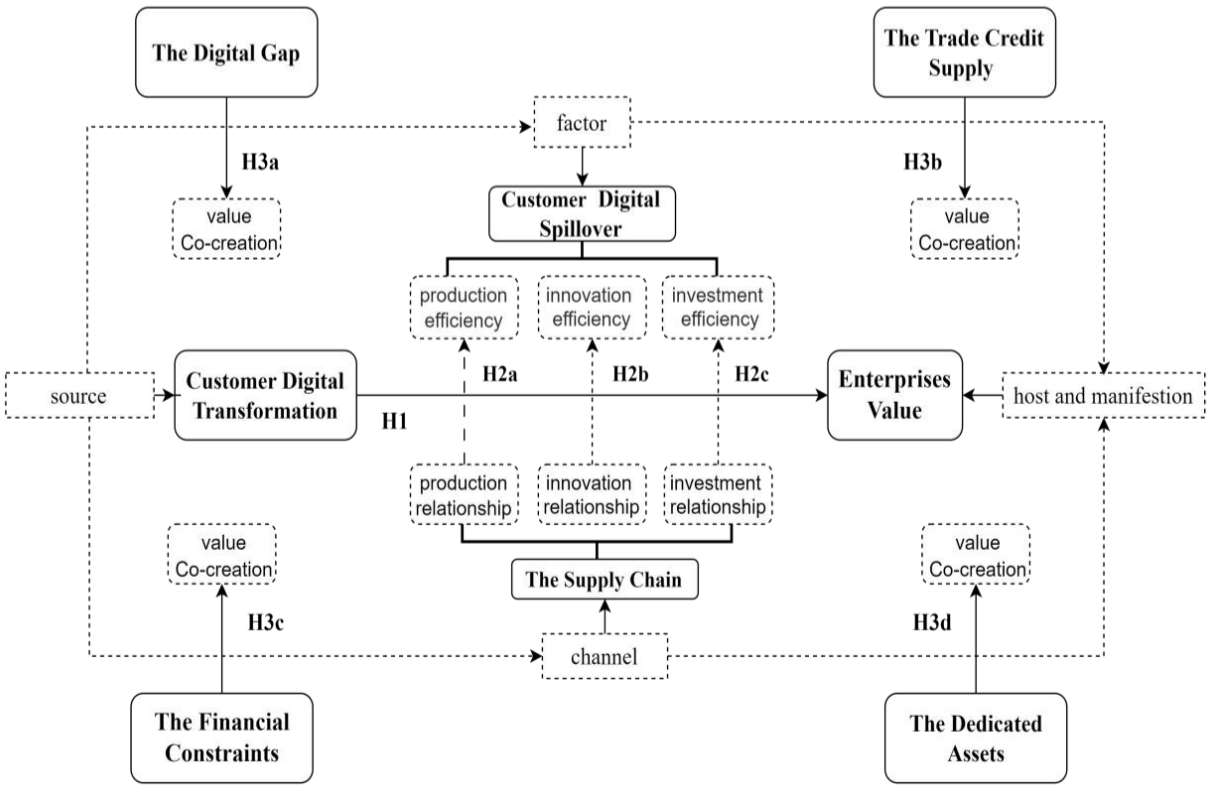

Figure 1. The Research Idea Diagram

4. Research Design

4.1. Sample Selection and Data Sources

In order to match the enterprise-customer-year starting sample, this study employs the top five customer data given with the genuine name in the Chinese A-share listed enterprises' annual reports from 2007 to 2021. The following procedures are used in this research to screen the samples based on the initial enterprise-customer-year samples: First, eliminate sample observations whose customers are not listed enterprises; second, eliminate ST, *ST, and PT sample observations; third, eliminate the financial industry sample observations; fourth, eliminate the sample observation of a single business that discloses the name of the customer but not their precise sales volume; and fifth, eliminate the sample observations that have missing values in the financial data.

In the end, A total of 1,755 enterprise-customer-year matching observations were obtained. There are numerous instances where a particular business (J) matches multiple customers (W, Y, and P) in the same year (2015). At the same time, to eliminate the influence of outliers, this research Winsorize all continuous variables on 1% and 99% quantiles. The fixed effects of industry and year were controlled in the regression model. In fact, using the top five listed customers of listed enterprises to build research samples has the following advantages: First, the interference of some unobstructed factors on research results can be controlled through the pairing relationship between enterprises; Second, the data of the top five listed customers used are more concentrated and consistent in caliber, which is helpful to reduce the problems caused by extreme values.

The data used mainly includes three parts. The first is the data of the digital transformation degree of listed enterprises, which is obtained by text analysis according to existing research practices. The second is the matching data between enterprises and customers and the financial data of listed enterprises,which mainly come from the China Research Data Service Platform Database (CNRDS) and the China Stock Market & Accounting Research Database (CSMAR).

4.2. Variable Definition and Model Setting

This research constructs the following regression model and takes the OLS regression model to test the spillover effect of customer digital transformation on enterprise value:

$$\begin{aligned} TOBIN_{i,t} = {} & \beta_0 + \beta_1 \mathrm{DIG}_{i,t-1} + \beta_2 LEV_{i,t} + \beta_3 SIZE_{i,t} + \beta_4 SOE_{i,t} + \beta_5 \mathrm{LHR}_{i,t} \\ & + \beta_6 DUAL_{i,t} + \beta_7 \mathrm{INDEP}_{i,t} + \beta_8 \mathrm{ROA}_{i,t} + \beta_9 \mathrm{GDP}_{i,t} + \beta_{10} \mathrm{CUS\_VOL}_{i,t-1} \\ & + \beta_{10} \mathrm{CUS\_AGE}_{i,t-1} + \sum YEAR + \sum IND + \delta_{i,t} \end{aligned} \quad (1)$$

Where, the subscript i and t represent the enterprise and the year respectively, and the characteristic variables of the customer all adopt one period lag; Customer digital transformation (DIG) is the core explanatory variable; Enterprise value (TOBIN) is the core explained variable. To eliminate the systematic interference that may be caused by the fixed characteristics of various industries that do not change with time, the fixed effect of industry is controlled .To eliminate the trend of firm value changing over time, this research also controls the year fixed effect.To reduce the interference of unobserved confounders on the identification of causal effect , this research is

based on existing studies (Bai et al., 2005) further added a series of influencing factors related to firm value. The specific variables are defined in Table 1.

Table 1. Main Variable Definitions

Categories	Name	Symbol	Definition
Dependent variable	Enterprise value	TOBIN	(equity market value + debt market value)/ending total assets
Independent variable	Degree of customer digital transformation	DIG	Take logarithm of the frequency of text keywords for enterprise digital transformation by adding 1
Enterprise characteristic variable	Asset liability ratio	LEV	Ratio of total ending liabilities to total ending assets
	Enterprise size	SIZE	Add 1 to total ending assets to take the natural logarithm
	Nature of the Enterprise	SOE	If it is a state-owned enterprise, the value is 1, otherwise it is 0
	The shareholding ratio of the largest shareholder	LHR	The ratio of the number of shares held by the largest shareholder to the number of shares held by the total shareholders
	The combination of two positions	DUAL	The value is 1 if both jobs are in one, otherwise it is 2
	Proportion of independent directors	INDEP	Number of independent directors as a percentage of the total number of directors on the board
	Return on total assets	ROA	Ratio of operating profit to total assets at the end of the period
Customer characteristic variable	Customer age	CUS_AGE	Take the natural logarithm of the listed age of the business by adding 1
	Customer sales revenue volatility	CUS_VOL	Volatility of customer sales revenue weighted by sales share
Macro level variables	Economic growth	GDP	Take the natural logarithm of gross domestic product per capita by adding 1
Fixed effect	Industry	IND	Control the influence of the industry
	Year	YEAR	Control the impact of the year

5. Empirical Tests and Result Analysis

5.1. Descriptive Statistics

Descriptive statistics of the main variables are shown in Table 2. The mean value of enterprise value (TOBIN) is 1.945 and the standard deviation is 1.234, indicating that the enterprise value of different enterprises varies greatly. The mean and standard deviation of enterprise digital transformation (DIG) are 2.561 and 1.074 respectively, and the minimum and maximum values are 0.000 and 5.273 respectively, indicating that the degree of digital transformation of listed enterprises in China is quite different, and there is still much room for improvement in the degree of digital transformation of some enterprises. And the control variables' distribution characteristic is basically similar to that of previous research literatures.

Table 2. Descriptive Statistics

Variable	N	Mean	SD	Min	p25	p50	p75	Max
TOBIN	1755	1.945	1.234	0.856	1.226	1.529	2.154	8.201
DIG	1755	2.561	1.074	0.000	1.792	2.485	3.219	5.273
LEV	1755	0.422	0.214	0.045	0.250	0.418	0.581	0.908
SIZE	1755	21.97	1.282	19.66	20.96	21.77	22.79	25.42
SOE	1755	0.426	0.495	0.000	0.000	0.000	1.000	1.000
LHR	1755	0.369	0.153	0.102	0.245	0.340	0.480	0.760
DUAL	1755	1.782	0.413	1.000	2.000	2.000	2.000	2.000
INDEP	1755	0.365	0.047	0.333	0.333	0.333	0.375	0.556
ROA	1755	0.037	0.064	-0.292	0.013	0.040	0.069	0.193
GDP	1755	10.85	0.521	9.122	10.46	10.87	11.21	12.12
CUS_VOL	1755	1.813	2.435	0.065	0.498	1.019	1.982	14.38
CUS_AGE	1755	2.236	0.782	0.000	1.946	2.485	2.773	3.258

5.2. Customer Digital Spillover and Value Co-creation

The regression results of the spillover effect of customer digital transformation on enterprise value are shown in Table 3. The results show from the perspective of statistical significance, the regression coefficients of customer digital transformation and enterprise value are both significant at the level of 1%, which proves that customer digital transformation has a positive spillover effect on enterprise value.Therefore, the hypothesis H1 is verified.

Table 3. Customer Digital Spillover and Value Co-creation

	(1)	(2)	(3)
	TOBIN	TOBIN	TOBIN
DIG	0.107***	0.099***	0.098***
	(3.07)	(3.19)	(3.13)
LEV		0.853***	0.850***
		(4.63)	(4.62)
SIZE		-0.542***	-0.537***
		(-15.63)	(-15.46)
SOE		0.123**	0.125**
		(1.97)	(2.00)
LHR		-0.707***	-0.710***
		(-3.66)	(-3.69)
DUAL		0.135**	0.133**
		(2.19)	(2.16)
INDEP		1.039*	1.048*
		(1.92)	(1.92)
ROA		1.947***	1.945***
		(2.68)	(2.68)
GDP		-0.024	-0.015
		(-0.40)	(-0.25)
CUS_VOL			0.012
			(1.11)
CUS_AGE			-0.028
			(-0.77)
_cons	1.253***	12.269***	12.122***
	(4.54)	(8.71)	(8.53)
IND	Yes	Yes	Yes
YEAR	Yes	Yes	Yes
N	1755	1755	1755
Adj. R^2	0.213	0.387	0.387

5.3. Robustness Tests

5.3.1. Instrumental Variable Method

The enterprise value will affect the success implementing probability of customer digital transformation. For example, higher enterprise value will send a signal to the asset market of the

strength of upstream companies and stable supply, which will affect the degree of support of market investors for customers to implement digital transformation. When investors' support for customers' implementation of digital transformation is high, it will effectively alleviate the financing constraints faced by customers' implementation of digital transformation, and then affect the digital transformation of customers. Therefore, to overcome the interference of reverse causality, the mean value of customer digital transformation in the same industry in the same year (DIG_IND) and the mean value of customer digital transformation in the same province in the same year (DIG_PROV) are selected as the instrumental variables of customer digital transformation (DIG). The regression results obtained by using the two-stage least square method are shown in Table 4. This result proves that reverse causality does not affect the positive spillover effect of customer digital transformation on firm value.

Table 4. Instrumental Variable Method

	(1)	(2)	(3)	(4)
	STAGE 1	STAGE 2	STAGE 1	STAGE 2
	DIG	TOBIN	DIG	TOBIN
DIG_IND	0.815***		0.817***	
	(23.22)		(23.39)	
DIG_PROV	0.446***		0.449***	
	(10.74)		(10.81)	
DIG		0.301***		0.295***
		(6.32)		(6.28)
LEV	-0.115	0.721***	-0.120	0.723***
	(-1.00)	(3.56)	(-1.04)	(3.60)
SIZE	-0.023	-0.461***	-0.015	-0.470***
	(-1.30)	(-14.23)	(-0.80)	(-14.27)
SOE	-0.023*	0.116*	-0.086*	0.116*
	(1.87)	(1.88)	(1.91)	(1.88)
LHR	-0.071	-0.403**	-0.089	-0.392**
	(-0.56)	(-2.13)	(-0.71)	(-2.11)
DUAL	-0.027	0.242***	-0.028	0.241***
	(-0.58)	(3.50)	(-0.59)	(3.48)
INDEP	0.399	0.328	0.404	0.390
	(1.14)	(0.57)	(1.16)	(0.66)
ROA	-0.332	1.632**	-0.307	1.615**
	(-1.04)	(2.33)	(-0.96)	(2.32)
GDP	-0.055	-0.089	-0.043	-0.102*
	(-1.21)	(-1.58)	(-0.95)	(-1.77)

CUS_VOL			0.022**	-0.019**
			(3.04)	(-1.96)
CUS_AGE			-0.030	0.060
			(-1.20)	(1.57)
_cons	0.419	11.427***	0.419	11.667***
	(0.77)	(13.51)	(0.77)	(13.57)
IND	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes
N	1755	1755	1755	1755
Adj. R^2	0.508	0.195	0.508	0.198
Correlation Test				
Partial R^2	0.439		0.441	
F-value	675.39		680.40	
Exogeneity Test				
Chi2		2.287		2.462
P-value		0.131		0.117

5.3.2. Sample Selection Bias

The interference of sample self-selection bias that Chinese listed enterprises have a voluntary tendency to disclose information to the top five customers, this research adopts the Heckman two-stage model to re-estimate. The regression results again confirmed that the basic results are robust.

Table 5. Regression of Heckman Two-stage Model

	(1)	(2)	(3)
	DIG_H	TOBIN	TOBIN
DIG		0.078**	0.079**
		(2.25)	(2.27)
IMR		-1.363	-1.268
		(-0.77)	(-0.72)
LEV	-1.274**	0.905***	0.898***
	(-2.31)	(3.31)	(3.27)
SIZE	0.137*	-0.565***	-0.568***
	(1.91)	(-13.36)	(-13.42)
SOE	-0.077	0.127**	0.124**
	(-0.38)	(2.00)	(1.97)
LHR	-1.442***	-0.532*	-0.529*
	(-2.65)	(-1.90)	(-1.89)

DUAL	0.092	0.193***	0.195***
	(0.44)	(3.22)	(3.25)
INDEP	4.064	0.847	0.797
	(1.55)	(1.20)	(1.12)
ROA	-2.435	2.309***	2.279***
	(-1.52)	(3.09)	(3.04)
GDP	0.329*	-0.079	-0.083
	(1.81)	(-1.01)	(-1.06)
CUS_VOL			-0.013
			(-1.44)
CUS_AGE			-0.020
			(-0.56)
_cons	-4.632*	14.041***	14.236***
	(-1.80)	(9.46)	(9.59)
IND	Yes	Yes	Yes
YEAR	Yes	Yes	Yes
N	1600	1571	1571
Adj. R^2	0.321	0.419	0.419

5.3.3. Different Customer Transaction Amounts

Because the transaction amounts of the top five customers disclosed by listed companies in China are different, this research constructs DIG_A based on the sales weight calculated by the customer's own sales in the sales of the top five customers, and DIG_B based on the sales weight calculated by the sales weight of the customer's own sales in the total sales of the enterprise to overcome the interference of the transaction amounts weight of different customers.The regression results are shown in Table 6.This result proves that the basic results have not changed substantially.

Table 6. Exclude the Interference of Different Customer Transaction Amounts

	(1)	(2)	(3)	(4)
	TOBIN	TOBIN	TOBIN	TOBIN
DIG_A	0.003***	0.003***		
	(8.07)	(8.17)		
DIG_B			0.113**	0.141**
			(2.13)	(2.42)
LEV	0.788***	0.789***	0.805***	0.811***
	(4.15)	(4.16)	(4.20)	(4.24)

SIZE	-0.554***	-0.558***	-0.537***	-0.541***
	(-15.22)	(-15.26)	(-15.20)	(-15.20)
SOE	0.124**	0.122*	0.114*	0.109*
	(1.96)	(1.94)	(1.83)	(1.76)
LHR	-0.728***	-0.716***	-0.733***	-0.711***
	(-4.02)	(-3.99)	(-4.02)	(-3.95)
DUAL	0.206***	0.207***	0.193***	0.194***
	(3.40)	(3.42)	(3.19)	(3.21)
INDEP	1.241**	1.169**	1.230**	1.113**
	(2.35)	(2.19)	(2.34)	(2.08)
ROA	2.105***	2.090***	2.180***	2.174***
	(3.10)	(3.07)	(3.24)	(3.25)
GDP	-0.033	-0.038	-0.038	-0.051
	(-0.54)	(-0.61)	(-0.62)	(-0.83)
CUS_VOL		-0.010		-0.022**
		(-1.13)		(-2.14)
CUS_AGE		-0.027		-0.035
		(-0.74)		(-0.97)
_cons	13.757***	13.988***	13.417***	13.793***
	(11.11)	(11.21)	(11.02)	(11.25)
IND	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes
N	1752	1752	1752	1752
Adj. R^2	0.414	0.414	0.416	0.417

5.3.4. The Reliability of the Top Five Customer Data

To verify the reliability of top five customer data of sample enterprises , this research takes the top three customers of sample enterprises as sub-samples to re-estimate. The regression results are shown in Table 7. This result verifies the reliability of the data of the top five customers of the sample enterprises and the basic results.

Table 7. The Regression of the Top Three Customer Subsamples

	(1)	(2)	(3)
	TOBIN	TOBIN	TOBIN
DIG	0.102**	0.086**	0.087**
	(2.45)	(2.29)	(2.32)

LEV		0.860***	0.863***
		(3.73)	(3.76)
SIZE		-0.541***	-0.547***
		(-12.25)	(-12.33)
SOE		0.175**	0.173**
		(2.26)	(2.23)
LHR		-0.773***	-0.751***
		(-3.43)	(-3.36)
DUAL		0.292***	0.296***
		(3.89)	(3.92)
INDEP		1.101*	0.958
		(1.79)	(1.52)
ROA		2.978***	2.972***
		(4.17)	(4.16)
GDP		-0.027	-0.036
		(-0.34)	(-0.46)
CUS_VOL			-0.013
			(-1.41)
CUS_AGE			-0.048
			(-0.96)
_cons	2.001***	12.824***	13.253***
	(4.45)	(9.01)	(9.06)
IND	Yes	Yes	Yes
YEAR	Yes	Yes	Yes
N	1013	1013	1013
Adj. R^2	0.258	0.436	0.436

5.3.5.The Sample's Multiple Situations

This research constructs DIG_MEAN and DIG_MEDIAN of top five customers of the same firm in the same year and replaces the explanatory variables in model (1) to re-estimate to overcome the interference of multiple customers of the same firm. The regression results are shown in Table 8. This result proves that the multi-pair situation of the study sample does not affect the basic results.

Table 8. Exclude the Interference of the Sample in the Multi-on-one Case

	(1)	(2)	(3)	(4)	(5)	(6)
	TOBIN	TOBIN	TOBIN	TOBIN	TOBIN	TOBIN
DIG_MEAN	0.111***	0.101***	0.101***			
	(2.82)	(2.83)	(2.81)			
DIG_MEDIAN				0.112***	0.100***	0.100***
				(2.86)	(2.85)	(2.83)
LEV		0.793***	0.795***		0.793***	0.794***
		(4.20)	(4.21)		(4.20)	(4.21)
SIZE		-0.550***	-0.554***		-0.550***	-0.554***
		(-15.19)	(-15.24)		(-15.19)	(-15.24)
SOE		0.115*	0.114*		0.115*	0.114*
		(1.85)	(1.83)		(1.85)	(1.83)
LHR		-0.698***	-0.685***		-0.700***	-0.687***
		(-3.91)	(-3.88)		(-3.92)	(-3.89)
DUAL		0.196***	0.197***		0.195***	0.196***
		(3.24)	(3.26)		(3.22)	(3.25)
INDEP		1.105**	1.038*		1.106**	1.039*
		(2.09)	(1.93)		(2.09)	(1.94)
ROA		2.131***	2.114***		2.117***	2.100***
		(3.15)	(3.13)		(3.13)	(3.11)
GDP		-0.057	-0.062		-0.056	-0.061
		(-0.92)	(-1.01)		(-0.91)	(-1.00)
CUS_VOL			-0.012			-0.012
			(-1.38)			(-1.38)
CUS_AGE			-0.019			-0.020
			(-0.53)			(-0.54)
_cons	2.207***	13.802***	14.041***	2.211***	13.801***	14.040***
	(6.25)	(11.09)	(11.20)	(6.25)	(11.09)	(11.19)
IND	Yes	Yes	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes	Yes	Yes
N	1755	1755	1755	1755	1755	1755
Adj. R^2	0.233	0.417	0.417	0.233	0.418	0.417

5.3.6. The Alternative Explanation

The supply chain digital transformation, mentioned in the Guiding Opinions on Actively Promoting Innovation and Application of Supply Chain issued by The State Council in 2017 May, also improves the adaptability, competitiveness and market value of enterprises by forming a customer-centered supply chain management reform using digital technology.This research uses the sub-sample from 2007 to 2017 to re-estimate to overcome this interference. The regression results are shown in Table 9. This result excludes the alternative explanations of supply chain digital transformation.

Table 9. Excluse Alternative Explanations: Supply Chain Digital Transformation

	(1)	(2)	(3)
	TOBIN	TOBIN	TOBIN
DIG	0.105***	0.097***	0.099***
	(2.68)	(2.82)	(2.85)
LEV		0.797***	0.797***
		(3.83)	(3.83)
SIZE		-0.546***	-0.549***
		(-13.91)	(-14.00)
SOE		0.106	0.104
		(1.58)	(1.55)
LHR		-0.745***	-0.733***
		(-3.90)	(-3.89)
DUAL		0.205***	0.207***
		(3.05)	(3.07)
INDEP		1.052*	1.014*
		(1.84)	(1.75)
ROA		2.277***	2.253***
		(2.87)	(2.83)
GDP		-0.072	-0.077
		(-1.11)	(-1.18)
CUS_VOL			-0.011
			(-1.14)
CUS_AGE			-0.004
			(-0.11)
_cons	1.717***	13.503***	13.669***
	(18.40)	(12.21)	(12.28)
IND	Yes	Yes	Yes
YEAR	Yes	Yes	Yes
N	1407	1407	1407
Adj. R^2	0.244	0.418	0.418

5.3.7. The Placebo Tests

Because some random factors may induce the improvement of enterprise value, this research adopts the randomly generated placebo test using Monte Carlo to simulate repeated regression model (1) for 500 times to support the basic results. The regression results are shown in Figure 2 and Figure 3. The results show the distributions of the obtained coefficients and P-values is near zero and follows normal distribution, which are in line with the expectations of placebo test. Therefore, the reliability of the basic results is confirmed once again.

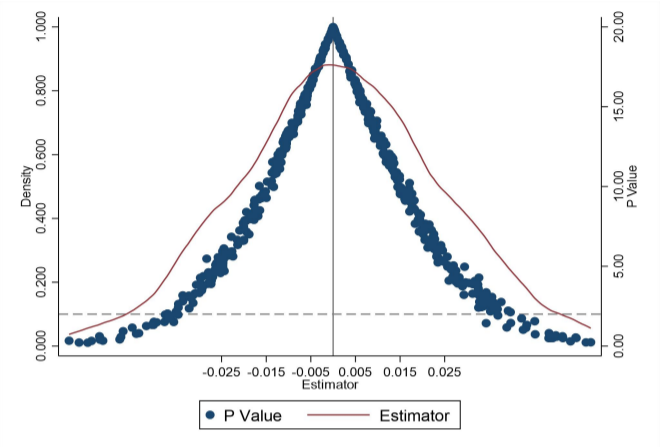

Figure 2. The placebo test of contains only the enterprise characteristics

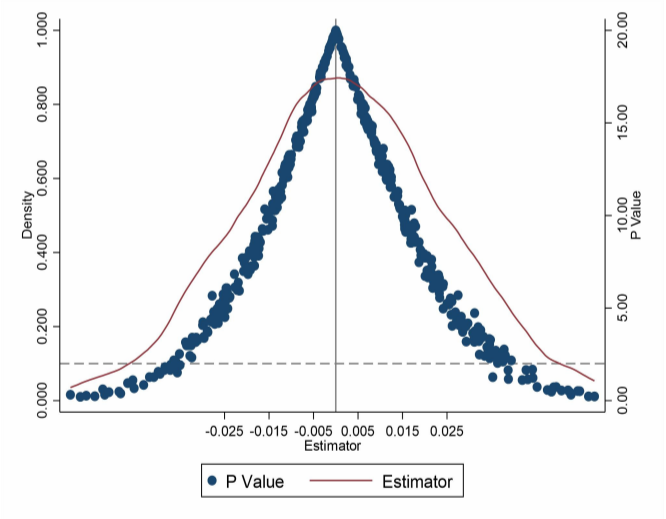

Figure 3. The Placebo Test of contains the enterprise characteristics and customer characteristics

5.3.8. The Potential Factors at the Level of Industries, Cities and Provinces

Some potential factors at the level of enterprises, industries, cities and provinces may interfere with the basic results, this research sets the clustering of industries, cities and provinces.Those results prove the basic results have not changed substantially.

Table 10. Clustering Results

	IND		CITY		PRO	
	(1)	(2)	(3)	(4)	(5)	(6)
	TOBIN	TOBIN	TOBIN	TOBIN	TOBIN	TOBIN
DIG	0.086*	0.087*	0.086**	0.087**	0.086***	0.087***
	(1.86)	(1.86)	(2.41)	(2.41)	(2.85)	(2.89)
LEV	0.792***	0.794***	0.792***	0.794***	0.792***	0.794***
	(3.23)	(3.25)	(2.84)	(2.85)	(3.07)	(3.08)
SIZE	-0.551***	-0.555***	-0.551***	-0.555***	-0.551***	-0.555***
	(-9.91)	(-9.97)	(-10.08)	(-10.09)	(-10.94)	(-11.02)
SOE	0.118	0.116	0.118	0.116	0.118	0.116
	(1.50)	(1.47)	(1.35)	(1.32)	(1.52)	(1.52)
LHR	-0.703***	-0.689**	-0.703***	-0.689***	-0.703***	-0.689**
	(-2.76)	(-2.66)	(-2.94)	(-2.89)	(-2.77)	(-2.70)
DUAL	0.196***	0.198***	0.196**	0.198**	0.196**	0.198**
	(2.92)	(2.95)	(2.31)	(2.32)	(2.61)	(2.62)
INDEP	1.120	1.045	1.120	1.045	1.120	1.045
	(1.50)	(1.42)	(1.39)	(1.30)	(1.31)	(1.22)
ROA	2.128**	2.111**	2.128**	2.111**	2.128**	2.111**
	(2.25)	(2.23)	(2.35)	(2.32)	(2.30)	(2.26)
GDP	-0.049	-0.056	-0.049	-0.056	-0.049	-0.056
	(-0.59)	(-0.70)	(-0.59)	(-0.67)	(-0.71)	(-0.80)
CUS_VOL		-0.012		-0.012		-0.012
		(-1.24)		(-1.33)		(-1.16)
CUS_AGE		-0.024		-0.024		-0.024
		(-0.56)		(-0.55)		(-0.51)
_cons	13.754***	14.017***	13.754***	14.017***	13.754***	14.017***
	(9.43)	(10.07)	(8.47)	(8.63)	(9.48)	(9.60)
IND	Yes	Yes	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes	Yes	Yes
N	1755	1755	1755	1755	1755	1755
Adj. R^2	0.417	0.417	0.417	0.417	0.417	0.417

5.3.9. The High Dimensional Fixed Effect Model

This research uses a high-dimensional fixed effects model to re-estimate to absorb the multi-layered fixed effects of panel linear regression. The regression results are shown in Table 12. Those results prove the basic results are robust.

Table 11. The Regression of High-dimensional Fixed Effect Model

	(1)	(2)	(3)	(4)	(5)	(6)
	TOBIN	TOBIN	TOBIN	TOBIN	TOBIN	TOBIN
DIG	0.074**	0.069**	0.070**	0.068**	0.063**	0.063**
	(2.11)	(2.17)	(2.19)	(2.00)	(2.04)	(2.03)
LEV		0.836***	0.839***		1.007***	1.011***
		(4.37)	(4.40)		(4.91)	(4.94)
SIZE		-0.549***	-0.553***		-0.564***	-0.566***
		(-14.60)	(-14.64)		(-13.14)	(-13.17)
SOE		0.129*	0.126*		0.119	0.114
		(1.85)	(1.81)		(1.34)	(1.27)
LHR		-0.777***	-0.761***		-0.773***	-0.760***
		(-4.15)	(-4.11)		(-3.18)	(-3.13)
DUAL		0.214***	0.216***		0.123	0.122
		(3.38)	(3.42)		(1.62)	(1.62)
INDEP		1.225**	1.169**		0.778	0.730
		(2.13)	(2.02)		(1.14)	(1.05)
ROA		2.170***	2.153***		2.324***	2.303***
		(3.17)	(3.14)		(3.06)	(3.04)
GDP		1.053***	1.020***		1.298***	1.268***
		(2.75)	(2.65)		(3.02)	(2.94)
CUS_VOL			-0.013			-0.005
			(-1.41)			(-0.54)
CUS_AGE			-0.021			-0.024
			(-0.60)			(-0.62)
_cons	1.740***	1.374	1.897	1.751***	-0.668	-0.234
	(20.08)	(0.33)	(0.46)	(20.96)	(-0.14)	(-0.05)
IND	Yes	Yes	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes	Yes	Yes
PRO	Yes	Yes	Yes	No	No	No
CITY	No	No	No	Yes	Yes	Yes
N	1749	1749	1749	1709	1709	1709
Adj. R^2	0.265	0.431	0.430	0.345	0.491	0.491

6. Further Research

6.1. The Channel Tests

6.1.1.The Improvement Enterprise Production Efficiency By Customer Digital Spillover

The enterprise system productivity of enterprise technology upgrading, management mode improvement, product quality improvement, and enterprise structure upgrading is represented by total factor productivity (Van, 2012). Consequently, enterprise total factor productivity, which is calculated by the LP method and the GMM method, serves as a proxy for enterprise production productivity. TFP_LP and TFP_GMM are the positive variable. Table 12 displays the results of the regression. According to the findings, enterprise value and consumer digital transformation have a favorable association since consumer digital spillover improves enterprise production efficiency.

Table 12. The Improvement Enterprise Production Efficiency By Customer Digital Spillover

	(1)	(2)	(3)	(4)
	TFP_LP	TFP_LP	TFP_GMM	TFP_GMM
DIG	0.031**	0.033**	0.043**	0.044**
	(2.23)	(2.34)	(2.48)	(2.53)
LEV	0.898***	0.908***	0.688***	0.694***
	(9.72)	(9.83)	(6.50)	(6.55)
SIZE	0.532***	0.529***	0.164***	0.163***
	(34.55)	(33.93)	(9.19)	(8.95)
SOE	0.057	0.057*	0.047	0.048
	(1.63)	(1.66)	(1.12)	(1.15)
LHR	0.262**	0.257**	0.117	0.112
	(2.55)	(2.51)	(0.93)	(0.89)
DUAL	0.038	0.039	0.014	0.015
	(1.22)	(1.25)	(0.36)	(0.38)
INDEP	0.284	0.323	0.469	0.525
	(0.91)	(1.03)	(1.20)	(1.33)
ROA	2.918***	2.952***	2.692***	2.715***
	(9.40)	(9.46)	(8.06)	(8.10)
GDP	0.201***	0.196***	0.328***	0.327***
	(5.39)	(5.24)	(7.35)	(7.37)
CUS_VOL		-0.005		0.001
		(-1.01)		(0.23)
CUS_AGE		0.043**		0.036
		(2.46)		(1.61)

_cons	-7.601***	-7.553***	-4.669***	-4.737***
	(-16.41)	(-15.96)	(-8.51)	(-8.45)
IND	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes
N	1450	1450	1450	1450
Adj. R^2	0.784	0.785	0.477	0.478

6.1.2. The Improvement Enterprise Innovation Efficiency By Customer Digital Spillover

Enterprise innovation efficiency is served by the proxy variable INN_EFF_1, which is calculated by ln(number of patent applications+1), and the proxy variable INN_EFF_2, which is calculated by (number of authorized patents)*10^7/(current R&D+lagging first phase R&D+lagging second phase R&D). INN_EFF_1 and INN_EFF_2 are the positive variable. Table 13 displays the results of the regression. According to the findings, enterprise value and consumer digital transformation have a favorable association since customer digital spillover improves enterprise innovation efficiency.

Table 13. The Improvement Enterprise Innovation Efficiency By Customer Digital Spillover

	(1)	(2)	(3)	(4)
	INN_EFF_1	INN_EFF_1	INN_EFF_2	INN_EFF_2
DIG	0.086***	0.087***	0.579*	0.556*
	(2.70)	(2.74)	(1.72)	(1.65)
LEV	-0.205	-0.202	1.829	1.923
	(-1.12)	(-1.10)	(0.83)	(0.87)
SIZE	0.708***	0.702***	-0.430	-0.539
	(21.85)	(21.41)	(-1.17)	(-1.46)
SOE	-0.079	-0.082	-0.849	-0.858
	(-1.06)	(-1.09)	(-0.88)	(-0.88)
LHR	0.915***	0.924***	-1.233	-1.150
	(4.18)	(4.23)	(-0.48)	(-0.45)
DUAL	-0.133*	-0.131*	-0.446	-0.403
	(-1.87)	(-1.84)	(-0.49)	(-0.44)
INDEP	0.267	0.200	0.866	-0.234
	(0.42)	(0.31)	(0.13)	(-0.03)
ROA	0.294	0.287	-3.499	-3.604
	(0.58)	(0.56)	(-0.64)	(-0.67)
GDP	0.156**	0.145**	0.189	0.071
	(2.15)	(1.99)	(0.21)	(0.08)

CUS_VOL		-0.016		-0.240***
		(-1.33)		(-2.97)
CUS_AGE		-0.003		-0.450
		(-0.07)		(-0.94)
_cons	-16.041***	-15.759***	7.974	13.061
	(-12.47)	(-12.02)	(0.75)	(1.19)
IND	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes
N	1754	1754	959	959
Adj. R^2	0.500	0.500	0.183	0.186

6.1.3. The Improvement Enterprise Investment Efficiency By Customer Digital Spillover

Enterprise investment efficiency is served by the proxy variable PEE which is calculated by (Total assets-Total current assets)/Total assets and the proxy variable ABS_INV which is calculated by the absolute value of enterprise investment efficiency calculated using the Richardson model (2006). PEE and ABS_INV are the negtive variable. Table 14 displays the results of the regression. According to the findings, enterprise value and consumer digital transformation have a favorable association since customer digital spillover improves enterprise investment efficiency.

Table 14. The Improvement Enterprise Investment Efficiency By Customer Digital Spillover

	(1)	(2)	(3)	(4)
	PPE	PPE	ABS_INV	ABS_INV
DIG	-0.014***	-0.014***	-0.002*	-0.003*
	(-3.23)	(-3.26)	(-1.74)	(-1.85)
LEV	-0.097***	-0.098***	-0.005	-0.006
	(-3.36)	(-3.38)	(-0.58)	(-0.63)
SIZE	0.035***	0.036***	0.000	0.001
	(7.74)	(7.88)	(0.28)	(0.53)
SOE	0.028**	0.028**	-0.016***	-0.016***
	(2.46)	(2.48)	(-4.80)	(-4.83)
LHR	-0.114***	-0.113***	0.019	0.020*
	(-3.20)	(-3.19)	(1.59)	(1.67)
DUAL	0.015	0.015	-0.003	-0.003
	(1.41)	(1.36)	(-0.73)	(-0.79)
INDEP	-0.068	-0.058	-0.045	-0.046
	(-0.77)	(-0.65)	(-1.62)	(-1.64)

ROA	-0.390***	-0.388***	0.008	0.008
	(-5.48)	(-5.42)	(0.37)	(0.38)
GDP	0.009	0.010	0.001	0.002
	(0.78)	(0.90)	(0.36)	(0.55)
CUS_VOL		0.003*		0.001*
		(1.65)		(1.76)
CUS_AGE		0.001		-0.003
		(0.21)		(-1.45)
_cons	-0.169	-0.214	-0.006	-0.020
	(-1.21)	(-1.51)	(-0.14)	(-0.41)
IND	Yes	Yes	Yes	Yes
YEAR	Yes	Yes	Yes	Yes
N	1358	1358	1358	1358
Adj. R^2	0.576	0.576	0.066	0.069

6.2. The Heterogeneity Tests

6.2.1. The Digital Gap

Drawing on the practice of Cho et al.(2023), this research sets the digital gap variable (DG), which is defined as the difference between the degree of customer digital transformation and the degree of enterprise digital transformation. DG is the positive variable. The regression results are shown in Table 15.The results show the effect of customer digital spillover on value co-creation is more significant in the sample of enterprises with wider digital gaps.

Table 15. The Heterogeneity About The Digital Gap

	(1)	(2)
	TOBIN	TOBIN
DIG×DG	0.065***	0.064***
	(4.32)	(4.25)
LEV	0.802***	0.799***
	(4.00)	(4.00)
SIZE	-0.574***	-0.569***
	(-15.85)	(-15.70)
SOE	0.075	0.077
	(1.13)	(1.16)
LHR	-0.505**	-0.507**
	(-2.40)	(-2.42)
DUAL	0.034	0.033

	(0.49)	(0.48)
INDEP	1.212**	1.221**
	(2.10)	(2.11)
ROA	2.307***	2.309***
	(3.09)	(3.09)
GDP	-0.023	-0.013
	(-0.35)	(-0.19)
CUS_VOL		0.014
		(1.16)
CUS_AGE		-0.026
		(-0.66)
_cons	12.000***	11.800***
	(10.52)	(10.27)
IND	Yes	Yes
YEAR	Yes	Yes
N	1583	1583
Adj. R^2	0.426	0.426

6.2.2. The Trade Credit Supply

Drawing on the practice of Lee and Rhee(2011), this research sets the trade credit supply variable (TC), which is defined (accounts receivable +notes receivable -accounts receivable in advance) / total assets. TC is the positive variable.The regression results are shown in Table 16.The results show the effect of customer digital spillover on value co-creation is more significant in the sample of enterprises with more trade credit supply.

Table 16. The Heterogeneity About The Trade Credit Supply

	(1)	(2)
	TOBIN	TOBIN
DIG×TC	0.401***	0.415***
	(3.08)	(3.13)
LEV	0.754***	0.754***
	(3.58)	(3.56)
SIZE	-0.561***	-0.562***
	(-14.41)	(-14.44)
SOE	0.153**	0.152**
	(2.28)	(2.27)
LHR	-0.684***	-0.679***

	(-3.29)	(-3.29)
DUAL	0.134**	0.134**
	(2.01)	(2.02)
INDEP	0.960	0.869
	(1.64)	(1.46)
ROA	2.685***	2.678***
	(3.64)	(3.62)
GDP	-0.007	-0.012
	(-0.11)	(-0.18)
CUS_VOL		-0.007
		(-0.69)
CUS_AGE		-0.043
		(-1.07)
_cons	11.511***	11.709***
	(9.75)	(9.83)
IND	Yes	Yes
YEAR	Yes	Yes
N	1426	1426
Adj. R^2	0.444	0.444

6.2.3. The Financing Constraints

Drawing on the practice of Kaplan and Zingales(1997), this research sets the financing constraints variable (KZ), which is defined as KZ index. KZ is the positive variable.The regression results are shown in Table 17.The results show the effect of customer digital spillover on value co-creation is more significant in the sample of enterprises with higher financial constraints.

Table 17. The Heterogeneity About The Financing Constraints

	(1)	(2)
	TOBIN	TOBIN
DIG×KZ	0.081***	0.081***
	(10.84)	(10.79)
LEV	-0.924***	-0.922***
	(-3.98)	(-3.97)
SIZE	-0.467***	-0.462***
	(-14.71)	(-14.62)
SOE	0.049	0.051

	(0.79)	(0.81)
LHR	-0.280	-0.282
	(-1.38)	(-1.40)
DUAL	-0.050	-0.051
	(-0.75)	(-0.78)
INDEP	0.919*	0.946*
	(1.70)	(1.74)
ROA	4.223***	4.225***
	(6.41)	(6.42)
GDP	-0.056	-0.046
	(-0.90)	(-0.73)
CUS_VOL		0.015
		(1.26)
CUS_AGE		-0.014
		(-0.39)
_cons	9.947***	9.720***
	(11.61)	(11.20)
IND	Yes	Yes
YEAR	Yes	Yes
N	1563	1563
Adj. R^2	0.511	0.510

6.2.4. The Dedicated Assets

Drawing on the practice of Handfield and Bechtel(2002), this research sets the dedicated assets variable (DA), which is defined as DA index. DA is the positive variable.The regression results are shown in Table 18.The results show the effect of customer digital spillover on value co-creation is more significant in the sample of enterprises with greater dedicated assets.

Table 18. The Heterogeneity About The Dedicated Assets

	(1)	(2)
	TOBIN	TOBIN
DIG×DA	0.270***	0.265***
	(3.38)	(3.30)
LEV	0.764***	0.761***
	(4.12)	(4.12)
SIZE	-0.529***	-0.524***
	(-15.38)	(-15.20)

SOE	0.120*	0.122**
	(1.94)	(1.97)
LHR	-0.652***	-0.654***
	(-3.37)	(-3.40)
DUAL	0.104*	0.102*
	(1.70)	(1.67)
INDEP	1.007*	1.010*
	(1.86)	(1.85)
ROA	1.901***	1.895***
	(2.60)	(2.59)
GDP	0.014	0.023
	(0.23)	(0.37)
CUS_VOL		0.012
		(1.18)
CUS_AGE		-0.034
		(-0.93)
_cons	11.820***	11.671***
	(8.51)	(8.32)
IND	Yes	Yes
YEAR	Yes	Yes
N	1750	1750
Adj. R^2	0.386	0.386

7. Research Conclusions and Implications

The real rate of return of the digital economy as a whole includes not only the direct productivity improvement brought by digital investment but also the additional economic benefits generated by the chain reaction of digital investment in the economic field, that is, digital spillover. Digital spillovers are the unintended or involuntary effects that occur independently of market mechanisms and actually affect other individuals or society as a whole. In general, the channels of digital spillover include industry, agglomeration, and the supply chain. As the economic linkage between enterprises formed through the supply chain is particularly common in the commodity market, such economic linkage not only facilitates the flow of factors and resources among the upstream and downstream enterprises but also provides a hidden way for the formation of a shared interest linkage mechanism among enterprises. Therefore, based on the reasonable and important research context provided by the supply chain,matching samples of listed enterprises in China's capital market from 2007 to 2021 and their top five customers, this research examines the customer digital spillover resulting from customer digital transformation on enterprise value.

The benchmark tests document customer digital spillover is positively associated with enterprise value co-creation in the supply chain, and this finding holds to a battery of robustness tests. Moreover, channel tests from the perspective of enterprise efficiency indicate that customer digital spillover impacts enterprise value co-creation in the supply chain through the improvement of enterprise production efficiency, enterprise innovation efficiency, and enterprise investment efficiency. Finally, the heterogeneity tests reveal that the effect of customer digital spillover on value co-creation among enterprises is more pronounced for enterprises with wider digital gaps, more trade credit supply, higher financial constraints and greater dedicated assets. In a word, this research which integrates upstream and downstream enterprises into a single research framework and deeply explores the interaction logic among enterprises, breaks the reality of the previous research on the supply chain spillover effect and value co-creation between enterprises.

This research has far-reaching policy implications. First, both customers and enterprises should not only make full use of resource elements brought by social capital, such as rich knowledge spillover, advanced technology spillover, and more accurate information spillover, but also actively promote digital transformation and take the initiative to carry out innovative research and development activities to build a supply chain community with competitive advantages to realize the value of the co-creation. Second, the government should pay attention to the phenomenon of the spillover effect in the digital transformation of enterprises at the micro level, deepen its understanding that digital spillover is one of the important sources of the core value of the digital economy, and take a series of measures to maximize the economic growth brought by digital spillover.

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