E-commerce Development and Enterprise Innovation: The Moderating Effect of Digital Transformation

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Abstract. With the continuous development of Internet technology, e-commerce, which is produced by the combination of commerce and Internet technology, has gradually grown and become a new business model. The importance of enterprises to Internet technology has also gradually deepened, and the new business model also has a profound impact on enterprise innovation. Through digital transformation, enterprises can apply Internet technology to daily production and operation activities. This paper selects the data of A-share listed companies to conduct an empirical analysis of e-commerce development and enterprise innovation, and uses digital transformation as a moderating variable. It is concluded that the development of e-commerce has an obvious promoting effect on enterprise innovation. The digital transformation has strengthened the positive effect of e-commerce and enterprise innovation. It also provides suggestions for promoting enterprise innovation, e-commerce development and accelerating digital transformation.

Keywords: E-commerce · Digital Transformation · Innovation

1 Introduction

With the development of Internet technology and the rapid iteration and dynamic evolution of information, informatization has become the trend of the times. The Internet, especially the mobile Internet, has increasingly become an important carrier of information dissemination and knowledge diffusion. According to the relevant data disclosed by the e-commerce Trading Platform of the National Bureau of Statistics, the total volume of e-commerce transactions in 2021 reached 42.3 trillion, an increase of 19.6% over the same period last year, and the online retail sales of physical goods reached 10.8 trillion, an increase of 12.0% over the previous year, accounting for 24.5% of the total retail sales of social consumer goods, and contributing 23.6% to the growth of retail sales of social consumer goods.

The e-commerce generated by the combination of commerce and the Internet is essentially a new business model, breaking the time and place constraints of the traditional business model, bringing new development ideas for enterprises, and also providing an opportunity for enterprises to further innovate. The development of e-commerce will enable enterprises to change their inherent thinking and methods, adopt thinking

and methods that are more suitable for the Internet technology and the Internet era, and further promote the development of enterprises' innovative activities.

With the gradual development of the Internet era, the digital economy is developing rapidly, and the national economy is accelerating into the digital economy era (Zhang Xiaheng et al., 2020) [19]. E-commerce is the most active and developing part of the digital economy. In the era of digital economy and e-commerce, enterprises have gradually begun digital transformation. The digital transformation of enterprises is to use the combination of artificial intelligence, cloud computing, blockchain, big data, Internet plus and other emerging technologies to carry out production and operation activities (Qiao Pengcheng&Zhang Yansong, 2023) [11], which has promoted enterprises to use Internet technology and digital technology to transform traditional business models and innovation models, and laid a solid foundation for enterprises to improve their innovation capabilities and achieve high-quality development.

2   Literature Review and Hypothesis Proposal

2.1   E-commerce Development and Enterprise Innovation

The development of e-commerce promotes the combination and innovation of enterprise marketing methods and Internet technology. The development of e-commerce means that online activities and transactions are more frequent. If enterprises want to use e-commerce to make profits, they must combine Internet technology to carry out production, sales, marketing and other activities. There is a big difference between traditional offline business and online business (Cheng Mingzhu, 2023) [2]. Online promotion mainly depends on the Internet, such as online live broadcast, online celebrity recommendation, community recommendation, etc., which is quite different from offline promotion. For enterprises, online marketing has greatly saved their manpower, material and financial resources (Yang Wenyue, 2023) [17], so enterprises will gradually incline to online marketing. The emergence and innovation of online marketing in enterprises is due to the development of e-commerce, which also needs to be carried out through Internet technology.

The development of e-commerce provides a good environment for enterprise innovation. Technological development is an important basis for enterprise innovation (Wei Jiang&Xu Qingrui, 1996) [13]. Enterprises can improve their independent innovation ability by introducing high-end Internet technology (Liu Xinxin&Hui Ning, 2021) [7]. E-commerce is an important achievement of Internet technology innovation, which has injected new vitality into various industries and enterprises. E-commerce has exerted certain pressure on the development and progress of enterprise Internet technology (Zhang Jiao, 2016) [18], and changed the development speed and direction of enterprise production technology. In the face of the new era of Internet, enterprises need independent innovation to maintain competitiveness (Liao Fangzheng, 2020) [6]. The application of e-commerce and other Internet technologies enables enterprises to create new business processes and forms based on market information (Lu Yu, 2022) [9] and create a good innovation environment for enterprises.

To sum up, the development of e-commerce promotes the innovation of enterprise marketing methods and provides a good environment for enterprise innovation. This paper puts forward the following assumptions:

Hypothesis 1: E-commerce development promotes enterprise innovation.

2.2 The Moderation Effect of Digital Transformation

In recent years, the digital economy has developed rapidly. For enterprises, digital transformation centered on digital technology application and digital elements is the core way to achieve high-quality development (Zhou Xiao, 2022) [20]. Enterprise digitalization is a systematic project composed of several digital technology modules (Gao Yingli, 2021). Digital transformation can reduce the cost of enterprise production and operation (Goldfarb&Tucker, 2019), help optimize the division of labor (Yuan Chun et al., 2021), promote the change of management mode (Qi Yudong&Xiao Xu, 2020) and improve innovation performance (Loebbecke&Picot, 2015) [9].

Digital transformation means that the development and application of digital technology in enterprises are gradually mature, which can provide technical support for the development of e-commerce. Enterprises with a strong degree of digital transformation can screen information conducive to their own e-commerce development in a complex and volatile environment, and quickly transform it into business opportunities. At the same time, digital transformation can independently capture external innovation opportunities and intelligently choose innovation paths, thus improving the innovation ability of enterprises (Qiao Pengcheng&Zhang Yansong, 2023) [11]. This means that in the process of e-commerce development and enterprise innovation, digital transformation has been providing technical support and assistance. Enterprises which have successfully achieved digital transformation can accelerate the development of e-commerce and innovation based on this technical support.

To sum up, this paper puts forward the following assumptions:

Hypothesis 2: Digital transformation strengthens the positive relationship between e-commerce development and enterprise innovation.

3 Data Collection and Measurement

3.1 Data Collection

This paper selects enterprises listed in A-share market in 2013–2021 for research, and excludes ST enterprises and financial and insurance enterprises on this basis; eliminate the delisted enterprises because their poor operating conditions and loss status will lead to abnormal data; eliminate the sample of enterprises listed in the observation year; eliminate the enterprise samples with serious missing or abnormal data of relevant research indicators in the process of data retrieval; After eliminating the enterprise samples with discontinuous data, 25227 samples were finally obtained.

3.2 Variable Measurement

(1) Dependent variable.

The dependent variable selected in this paper is enterprise innovation (Inno). There are many ways to measure enterprise innovation. Considering the integrity of the data, this paper mainly refers to the measurement method of Mou Weiwei and Liu Kefu (2023) [10]. The R&D investment of enterprises is used as an alternative indicator to measure enterprise innovation, and the data is logarithmized.

(2) Independent variable.

The independent variable selected in this paper is e-commerce development (ECD), mainly referring to the measurement method of Lu Yu (2022) [9]. Due to the high missing value of e-commerce sales of listed companies in the database, the e-commerce sales of each listed company's region is taken as the measurement method, and the data is logarithmized.

(3) Moderating variable.

Digital Transformation (DT). Referring to the practice of Wu Fei et al. (2021) [14], this paper uses Python crawler technology to sort, count and sum up the characteristic words such as digital technology application, cloud computing technology, artificial intelligence technology, big data technology, blockchain technology, etc. in combination with the annual report of A-share listed companies. In order to avoid the serious "right bias" characteristic of this kind of data, the data is logarithmized. At the same time, in order to avoid the occurrence of zero, the number $+ 1$ is taken as the logarithm, and finally the measurement index of enterprise digital transformation is formed.

(4) Control variables.

Referring to the factors that have influence on enterprise innovation in previous studies, the control variables of this paper are enterprise size (Size), enterprise financial risk (Lev), ownership concentration (Own), enterprise growth (Growth), industry (Industry) and year (Year) of listing. The specific measurement methods are as follows.

3.3 Assumption Model

Based on the above analysis, this paper believes that e-commerce development promotes enterprise innovation, and digital transformation plays a positive regulatory role in this relationship. In order to confirm the existence of this impact and mechanism, the following empirical model is constructed:

To test the impact of e-commerce development on innovation, this paper constructs a model (1) as a benchmark regression model:

$$
\begin{aligned}
\text{Inno}_{i,t} = {} & \beta_0 + \beta_1 \text{ECD} + \beta_2 \text{Size}_{i,t} + \beta_3 \text{Lev}_{i,t} + \beta_4 \text{Own}_{i,t} \\
& + \beta_5 \text{Growth}_{i,t} + \sum \text{Industry} + \sum \text{Year} + \varepsilon_{i,t}
\end{aligned} \tag{1}
$$

In order to test the moderation effect of digital transformation, this paper constructs models (2) and (3) as benchmark regression models.

$$\text{Inno}i, t = \beta0 + \beta1\text{ECD} + \beta2\text{DT}i, t + \beta3\text{Size}i, t + \beta4\text{Lev}i, t$$
$$+ \beta5\text{Own}i, t + \beta6\text{Growth}i, t + \sum \text{Industry} + \sum \text{Year} + \varepsilon_{i,t} \quad (2)$$

$$\text{Inno}i, t = \beta0 + \beta1\text{ECD} + \beta2\text{DT}i, t + \beta3\text{ECD}i, t * \text{DT}i, t + \beta4\text{Size}i, t + \beta5\text{Lev}i, t$$
$$+ \beta6\text{Own}i, t + \beta7\text{Growth}i, t + \sum \text{Industry} + \sum \text{Year} + \varepsilon_{i,t} \quad (3)$$

4 Empirical Results and Analysis

4.1 Descriptive Analysis

Table 2 shows the descriptive statistical results of enterprise innovation (Inno), e-commerce development (ECD), digital transformation (DT), enterprise size (Size), asset-liability ratio (LEV), equity concentration (Own) and enterprise growth (Growth). The gap between the maximum value and the minimum value of enterprise innovation is large, which indicates that different enterprises have a large gap in innovation, and so is the development of e-commerce. The average value of digital transformation is greater than the median value, which indicates that there are significant differences in digital transformation among enterprises. Some enterprises have already realized digital transformation, while some enterprises have been unable to transform.

4.2 Correlation Analysis

Table 3 shows the results of correlation analysis. According to the data in the table, e-commerce development and enterprise innovation are significantly positively correlated, which is consistent with the inference of hypothesis 1 in this paper. The development of e-commerce can promote enterprise innovation.

4.3 Regression Analysis

In order to verify the hypothesis, this paper carries out regression analysis based on the model built, and the results are shown in Table 4. According to the data in column (1), the regression coefficient between e-commerce development (ECD) and enterprise innovation (Inno) is 0.225, which is significant at the level of 1%, indicating that e-commerce development has a significant positive effect on enterprise innovation, which verifies the hypothesis 1 of this paper. In order to explore the moderation effect of digital transformation on e-commerce development and enterprise innovation, based on model (1), digital transformation (DT) and the product of e-commerce development (ECD) and digital transformation (DT), ECD * DT, are introduced. According to the data in column (3), the coefficient of the product ECD * DT is 0.040, which is significant at the level of 1%, indicating that digital transformation is positively regulating the positive effect of e-commerce development and enterprise innovation. Hypothesis 2 is verified.

Table 1. Variable definition and measurement

Variable type	Variable name	Variable code	Measurement method
Dependent variable	enterprise innovation	Inno	the logarithm of enterprise R&D investment
Independent variable	e-commerce development	ECD	the logarithm of electronic sales in the region where the enterprise is located
Moderating variable	digital transformation	DT	The word frequency of artificial intelligence technology, blockchain technology, cloud computing technology, big data technology and digital technology application in the annual report is added and logarithmic
Control variables	enterprise size	Size	the logarithm of the total assets of the enterprise
	financial risk	Lev	asset-liability ratio
	ownership concentration	Own	shareholding ratio of the top ten shareholders
	enterprise growth	Growth	enterprise revenue growth rate
	year	Year	years of listing
	industry	Industry	Industry name

Table 2. Descriptive analysis results

variable	N	mean	p50	sd	min	max
Inno	25227	7.755	7.753	0.684	2.212	10.87
ECD	25227	3.846	3.938	0.502	1.497	4.578
DT	25227	0.671	0.602	0.621	0	2.736
Size	25227	9.627	9.536	0.582	7.503	12.83
Lev	25227	0.502	0.392	14.43	0.00400	2293
Own	25227	59.82	60.72	15.64	0	101.2
Growth	25227	0.843	0.137	31.91	-28.59	4500

Table 3. Correlation analysis result

	Inno	ECD	DT	Size	Lev	Own	Growth
Inno	1						
ECD	0.188***	1					
DT	0.196***	0.243***	1				
Size	0.540***	-0.012*	0.044***	1			
Lev	-0.016**	-0.012**	-0.00400	-0.016***	1		
Own	-0.013**	0.077***	-0.051***	0.040***	-0.018***	1	
Growth	-0.021**	-0.006**	0.01**	0.005**	0.001**	0.014**	1

*** $p < 0.01$,** $p < 0.05$,* $p < 0.1$

Table 4. Regression analysis results

	(1)	(2)	(3)
	Inno	Inno	Inno
ECD	0.225***	0.202***	0.229***
	(31.375)	(20.455)	(31.541)
DT		−0.013	0.140***
		(-0.275)	(23.871)
ECD*DT			0.040***
			(3.392)
Size	0.632***	0.632***	0.632***
	(105.454)	(105.496)	(105.496)
Lev	−0.002***	−0.002***	−0.002***
	(−7.056)	(7.068)	(−7.068)
Own	−0.002***	−0.002***	−0.002***
	(−7.923)	(−7.745)	(−7.745)
Growth	−0.03***	−0.003***	−0.003***
	(−9.399)	(−9.379)	(−9.379)
Industry	Control	Control	Control
Year	Control	Control	Control
_cons	0.814***	0.898***	0.796***
	(12.590)	(12.972)	(12.266)
N	25227	25227	25227

*** $p < 0.01$,** $p < 0.05$,* $p < 0.1$

5   Conclusion

According to the above research, it can be concluded that e-commerce development promotes enterprise innovation. Enterprises need to develop new e-commerce in combination with advanced Internet technology, promote innovative activities of enterprises, and ultimately achieve high-quality enterprise development. Digital transformation plays an indispensable role in it. It can improve the efficiency of enterprises using Internet technology. At the same time, enterprises need to introduce more talents proficient in Internet technology, improve the overall thinking of the Internet, and actively develop new production and management methods in the Internet era.

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