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The Impact of Digital Transformation on Product Innovation - Mediated by Business Model Innovation

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Abstract. Based on the dynamic capability theory, this paper proposes a moderated mediation model to examine the role mechanism of digital transformation affecting enterprise product innovation and its boundary conditions. By empirically analyzing 123 survey data from new energy automobile enterprises, the results show that there is a significant positive impact of digital transformation on product innovation; business model innovation plays a mediating role between digital transformation and enterprise product innovation; and knowledge sharing plays a moderating role in the mechanism of this process. The conclusions of the study provide new insights into the relationship between digital transformation and enterprise product innovation, as well as a new contribution to the theoretical study of business model innovation, and also provide theoretical support and practical reference for enterprises to further construct digital transformation, innovative business model frameworks, and to build knowledge sharing platforms.

Keywords: digital transformation, business model innovation, product innovation, knowledge sharing

1. Introduction

As the digital economy continues to evolve, digital technologies are gradually penetrating all aspects of socio-economic activities, and digital transformation has become a key driver of the digital economy era [1]. Especially during the COVID-19 pandemic, when the majority of people chose to work from home, the urgency of digital transformation increased significantly [2]. The urgency of digital transformation has also come with the arrival of the digital economy, which continues to incorporate new technologies, business models, and operations into the transformation process, thereby promoting an innovation-driven economic model [3]. Thus, digital transformation provides new opportunities for product innovation, while product innovation, as the core of a firm's continued competitiveness, combining the two effectively is key to maintaining firm competitiveness and driving economic growth [4].

Dynamic capability theory states that in complex and changing market environments, firms need the ability to identify, acquire, integrate, configure and reconfigure internal and external resources in order to better maintain a competitive advantage in the marketplace [5]. Based on the dynamic capabilities theory and with the rapid advancement of the digital economy, companies are faced with drastic changes in the business environment and market demands, which force them to redefine their products and services through digital transformation [6]. Digital transformation is not just a change in technology, it is a comprehensive change involving corporate culture, organizational structure and business models [7]. This change has made product innovation a key driver for sustained growth, especially in a high-tech industry like new energy vehicles. In the new energy vehicle industry, digital transformation is shaping the future of mobility. It transforms the vehicle into a "smartphone on wheels", introducing entertainment and information services and making platform providers, such as navigation and entertainment software, central players. This transformation not only facilitates the transition of traditional automakers to digital business models, but also promotes a service-oriented driving experience that accelerates product innovation [8]. This demonstrates that digital transformation has transformed the automobile from just a means of transportation to an entertainment and information platform that provides diverse services. Especially in the field of new energy vehicles, which are shifting to sustainable development, digital transformation has shaped the future of the automotive industry by providing more convenient services to users. Therefore, this paper will pay particular attention to the study of the impact of digital transformation on product innovation in the new energy industry.

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Although the existing literature has to some extent explored the impact of digital transformation on product development, business models, enterprise internationalization, and organizational innovation, relatively little attention has been paid to product innovation. Product innovation in the digital era not only requires firms to focus on technological advancement and quality improvement, but must also take into account changes in market demand, insights into user behavior, and knowledge complementarity with partners [9]. As a result, this paper selects business model innovation as the mediating variable. At the same time, considering the importance of knowledge transfer in the innovation process, this paper will focus on the moderating role played by knowledge sharing in it.

Accordingly, this paper will explore the relationship between digital transformation and enterprise product innovation based on dynamic capability theory, and choose the mediating variable as business model innovation and knowledge sharing as the moderating variable. Through questionnaire survey, this study aims to verify the above hypotheses in order to reveal how new energy automobile enterprises can utilize digital transformation to promote innovation in the era of digital economy, and strengthen this effect through business model innovation and effective knowledge sharing mechanism. This not only enriches the application of dynamic capability theory in the context of digital economy, but also provides theoretical guidance and practical strategies for enterprises to implement digital transformation, especially in promoting product innovation.

2. Literature Review

In recent years, with the rapid development of digital technology, the impact of digital transformation on the product innovation of enterprises has become the focus of academic attention. Vial's (2021) [1] study argues that digital transformation is an all-encompassing process of change in the relevant business activities of enterprises through the integrated use of information, computation, communication, and the introduction of technology. Nadkarni and Prügl (2021) [6] define digital transformation as an organizational change that is enabled by digital technology. This means that digital transformation involves both technical and managerial players in the organization and opens up new business models while changing the old business technology processes. Gong and Ribiere (2021) [7] consider digital transformation as a fundamental transformation in strategy, processes, operations, culture, structure, and mindset to recreate the value of an organization by adopting digital technologies that create new value.

Existing research has focused on the impact of digital transformation, mainly on the impact of digital transformation on product development, corporate culture, business models, corporate internationalization, etc. Foss and Saebi (2017) [11] explore the progress of the research on business model innovation, and argued that digital transformation drives companies to innovate from the traditional model of selling products to providing integrated service products transformation. This innovation in digital business models not only improves the market adaptability of companies, but also provides consumers with more personalized and high-value products and services. In addition to this, Kane et al. (2019) [12] analyzed the impact of digital transformation on organizational structure and culture, and how these factors further drive product innovation. The study suggests that digital transformation requires firms to update their culture to accommodate digital development, which is crucial for product innovation. Scholars such as Kraus (2021) [13] argue that digital transformation brings disruptive innovations. These innovations are usually realized by redesigning products and services and developing new business models. Digital transformation is not only a process of technological advancement, but also an opportunity to comprehensively reshape the market landscape for products and services. Scholars such as Feliciano-Cestero and others (2023) [14] have shown that digital transformation has had a significant impact on the internationalization of firms, driven by factors such as knowledge, leadership, digital servitization, and technology. However, it also faces challenges such as lack of technical knowledge, inadequate infrastructure, security risks and cultural barriers. It also shows that while digital transformation promotes internationalization and product innovation, it also poses challenges such as technological gaps and cultural barriers, requiring companies to adapt their strategies and innovate their products in order to gain a competitive advantage.

However, the development of product innovation in the digital era is also facing more changes and challenges. In the face of the challenges and opportunities brought by digital transformation, the paths and practices of product innovation have also changed significantly, but the existing research is relatively lacking in exploring the relationship between digital transformation and product innovation. The implementation of product innovation requires companies to not only focus on technological advancement and quality improvement, but also consider the impact of digital transformation, changes in market demand, insights into user behavior, and the selection of partners and complementary knowledge. Chen and other scholars (2021) [9] define product innovation as a continuous process of iterative design of products by firms utilizing resources to adapt to changes in technology and markets [9]. The study by Babina and other scholars (2021) [15] defines product innovation as the process of creating new products by utilizing artificial intelligence techniques to reduce product development costs and improve the quality of existing products. Zhan and other scholars (2017) [16] argue that digital transformation facilitates the resource and capability base for product innovation, in which big data on market changes and user behaviors establish a key resource for product innovation in enterprises. Khan and other scholars (2021) [17] argue that in the digital economy, in emerging economies and dynamic environments, firms need to innovate their products in order to further satisfy the needs of their customers and to achieve better growth for themselves. Gao (2023) [18] notes that digital transformation may help reshape product innovation. Therefore, focusing on specific industries and exploring the specific mechanisms of how digital transformation affects product innovation is an important topic with both theoretical and practical implications.

3. Research Hypotheses

3.1. Digital Transformation and Product Innovation

With the advent of the digital economy, enterprises are gradually realizing the importance of digital transformation in driving product innovation. Digital transformation not only brings new development opportunities for enterprises, but also plays an important role in promoting product innovation. First of all, digital transformation enables enterprises to capture innovation opportunities more acutely by enhancing their interaction with internal and external environments. This ability becomes especially important at a time when industries and markets are becoming increasingly competitive [19]. The capture of innovation opportunities through digitalization can promote enterprises to understand more clearly the channels of product innovation, and then promote the realization of product innovation. Second, digital transformation through the introduction of advanced digital technology to build a digital platform, so that enterprises can integrate more resources and information, including market information, technical knowledge and user needs, so as to promote product innovation [20]. Accordingly, we propose:

H1: Digital transformation positively affects product innovation;

3.2. The Mediating Role of Business Model Innovation

Business model innovation, as a way to further change the way companies engage in value creation and value capture, is a key mechanism for implementing digital transformation strategies [21]. This innovation can provide a framework for companies to integrate emerging digital technologies to innovate products [22]. At the same time digital transformation involves not only the application of technology, but also changes to business models, organizational structures and corporate culture. In order to successfully implement digital transformation, companies need to innovate their business models in order to achieve competitive advantage in the market [23]. In addition, the development of digital technologies is driving business model innovation, particularly in the areas of customer experience and value creation. Driven by digital technology, business model innovation can realize the renewal of the organization's business development process, which in turn drives the renewal of products. In this process of updating and iterating, enterprises carry out business model innovation by optimizing the value chain, developing business channels, etc., improving the efficiency of the use of resources, developing newer products, and promoting the speed and quality of product innovation to achieve the purpose of meeting the needs of users [24]. Therefore, through business model innovation, firms are able to develop new products or services to meet market demand [25]. Accordingly, we propose:

H2: Digital transformation positively affects business model innovation;

H3: Business model innovation positively influences product innovation;

H4: Business model innovation plays a mediating role between the relationship of digital transformation and product innovation;

3.3. The Moderating Role of Knowledge Sharing

Based on the Dynamic Capability Theory, firms need to continuously adapt to changes in the external environment in order to continuously acquire new knowledge and thus have new opportunities for growth amidst the changes in the environment [26]. Knowledge sharing, as a mechanism for the flow and exchange of resources within an organization, can significantly enhance an enterprise's innovative capacity and adaptability. When knowledge sharing is effectively implemented within an organization, it can contribute to the formation of a corporate culture in which the values of encouraging innovation, openness, and collaboration become an important driving force for digital transformation and business model innovation [27]. In addition, efficient knowledge sharing mechanisms can help firms to better utilize and integrate digital technologies, thus accelerating the business model innovation process [28]. Accordingly, we propose:

H5: Knowledge sharing positively moderates the relationship between digital transformation and business model innovation, i. e. the higher the degree of knowledge sharing, the stronger the relationship between digital transformation and business model innovation.

Combining the above hypothesized contents, since knowledge sharing positively moderates the relationship between digital transformation and business model innovation, and at the same time business model innovation plays a mediating role between digital transformation and product innovation, this study further proposes the moderated mediation hypothesis

H6: Knowledge sharing positively moderates the impact of digital transformation on product innovation through business model innovation, i. e., the higher the degree of knowledge sharing, the stronger the mediating effect played by business model innovation.

In summary, the theoretical model of this study is shown in Figure 1.

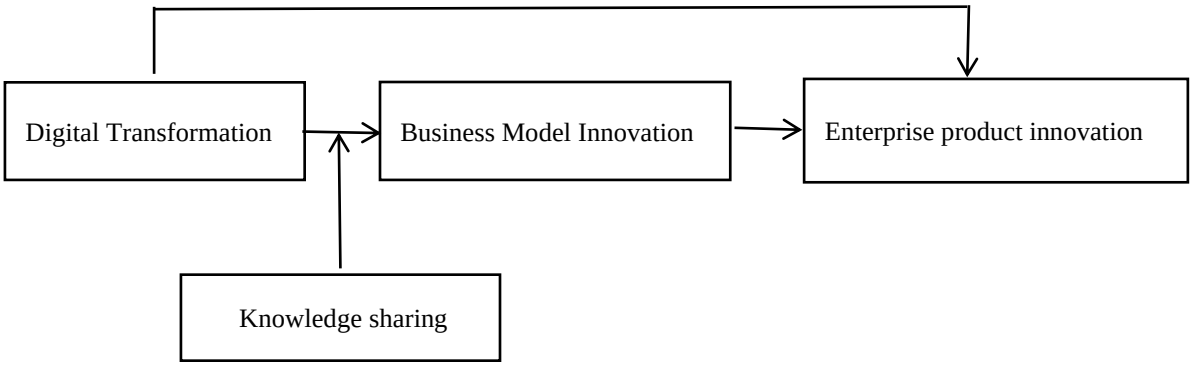

Figure 1. Theoretical Model

4. Methedology

4.1. Data Collection

This paper takes Chinese new energy automobile enterprises as the research object, and collects research data from middle and senior managers [29] of the enterprises through online questionnaires. The data collection process of this study was conducted from February to April 2024 using the questionnaire method. By utilizing the existing social network, we contacted the middle and senior management of the target company and after detailing the purpose of the study, a preliminary random sample pre-survey of the sample company was conducted. The questionnaires for this survey were filled out by managers who were familiar with matters related to corporate digitalization and innovation in order to collect data on, among other things, corporate digital transformation and innovation activities. The questionnaires were completed anonymously to ensure the security of the participating companies' information. A total of 150 questionnaires were distributed, and after excluding invalid data questionnaires such as broken response times and consecutive identical responses, there were 123 valid questionnaires, and the effective recovery rate of the questionnaires was 82%. Among the surveyed people, the enterprises are all privately owned, and the proportion of small-sized enterprises (less than 500 people) is relatively low, about 10%. Medium-sized enterprises (501 to 2,000 employees) constituted the majority of the survey, with nearly 40% of enterprises with 501 to 1,000 employees and about 27% of enterprises with 1,001 to 2,000 employees. Large-sized enterprises (more than 2,000 employees) also have a relatively significant proportion, at about 21%. The proportion of enterprises that have been established for less than 15 years is 61%.

4.2. Variable Measurement

All variables in this study were taken from the authoritative literature, and except for the control variables, all variables in this study were rated on a 5-point Likert scale, with 1 being "strongly disagree" and 5 being "strongly agree".

1. Firms' product innovation. Drawing on the research scale of Foss et al. (2011) [29], four question items were designed (see Table 4-1). The Cronbach'sAlpha coefficient for this scale is 0.888.

2. Digital transformation. Drawing on Wang Cai's (2023) [30] research scale, six question items were designed (see Table 1). The Cronbach'sAlpha coefficient of this scale is 0.956.

3. Business model innovation. Drawing mainly on the research scale of Clauss (2017) [31], question items were designed to analyze the ability of digital transformation on business model innovation of enterprises, in order to comprehensively reflect the performance of enterprises in business model innovation (see Table 1). The Cronbach's Alpha coefficient of this scale is 0.858.

4. Knowledge sharing, drawing on Lin and Lee's (2004) [32] research scale, designed with four questions (see Table 1). The Cronbach'sAlpha coefficient for this scale was 0.903.

5. Control variables: from the existing literature, it is known that in addition to the above variables, there are other variables that may have an impact on the product innovation of the enterprise, this study will be the ownership of the enterprise, the age of the enterprise, the size of the enterprise as a control variable (see Table 1).

Table 1. Scale items

Implicit Variable	Measurement Item
Product Innovation	(1) Compared with the industry average, our company launches new products to the market more quickly (2) Compared with the industry average, our company's new product

	success rate is higher
	(3) Compared with the industry average, our company has a higher share of new products
	(4) Higher profitability of our new products compared to the industry average
Independent Variable	Measurement Item
Digital Transformation	(1) Enterprises are operating digital technology-based business management processes.
	(2) Companies are transforming their business management processes around the use of digital technologies
	(3) Enterprises are using digital technology to transform and upgrade existing products, services and processes
	(4) Enterprises are fully promoting digital design, manufacturing and management model
	(5) The enterprise is developing digital products and services
	(6) The enterprise is spending efforts to promote and publicize digital skills and management knowledge.
Intermediary Variable	Measurement Item
Business Model Innovation	(1) We continuously attend training to learn and develop new competencies
	(2) We continually reflect and think about the latest capabilities needed to respond to changes in the marketplace.
	(3) We keep abreast of and utilize the latest technological advances wherever possible.
	(4) We constantly utilize new technologies to expand our product and service portfolio.
	(5) We are constantly looking for new partners
	(6) We advocate the concept of sharing and cooperation with our partners.
	(7) We take full advantage of the opportunities brought about by the introduction of new partners.
	(8) We utilize innovative processes and procedures in the production of our products.
	(9) We pay close attention to industry trends and constantly adjust our position in the business ecosystem.
	(10) We are highly attentive to new or unmet customer needs
	(11) Our products/services are more innovative and have a better user experience than those of our competitors.
	(12) We often find business opportunities in new or growing markets.
	(13) We are constantly looking for new customer segments and markets in which to promote our products/services.
	(14) We attempt to increase user stickiness by continually providing new product/service content.
	(15) we continually develop and implement innovative campaigns to increase user stickiness
	(16) We have recently developed new revenue opportunities (e. g. , add-on sales, cross-selling, etc.)
	(17) We have a differentiated revenue model compared to our competitors
	(18) We frequently innovate our pricing and quality strategies.
Moderator Variable	Measurement Item
Knowledge Sharing	(1) Expertise gained from work practices
	(2) Specialized knowledge gained from within the company (e. g. , exchange meetings)
	(3) Business knowledge gained from outside the organization (e. g. , customers, suppliers)
	(4) Business knowledge gained from informal channels (e. g. , news)

4.3. Reliability and Validity

Reliability: the Cronbach's Alpha coefficients of the scales used in this study were above the critical value of the reliability coefficient of 0.7, (see Table 2), and the results of the study indicate that the reliability of the data meets the requirements.

Table 2. Reliability test results of variables

Variant	Cronbach's a
Digital Transformation	0.888
Business Model Innovation	0.956
Product Innovation	0.858
Knowledge Sharing	0.903

Validity: the four-factor model containing digital transformation, business model innovation, product innovation and knowledge sharing fitted the results better, $\chi 2/df = 2.189$, RMSEA=0.068, IFI=0.972, CFI=0.971, TLI=0.959. The 3-factor model combined digital transformation and business model innovation into one factor, the 2-factor model combined digital transformation, product innovation and business model innovation into one factor, and the one-way model combines all variables into one factor. The 4-factor model was found to fit the data most optimally, indicating that the research variables in this study have good structural validity. And the squares of the person correlation coefficients between the variables are smaller than the amount of variance extracted from each variable, which satisfies the requirement of discriminant validity.

4.4. Descriptive Statistics and Correlation Analysis

Descriptive statistics and correlation analysis investigated the means, standard deviations, and correlation coefficients of four variables: the independent variable digital transformation, the mediating variable business model innovation, the dependent variable enterprise product innovation, and the moderator variable knowledge sharing. The results are shown in Table 3, and the study found that:

The relationship between digital transformation and corporate product innovation is significantly positive ($r = 0.533$, $p < 0.01$). There is also a significant positive relationship between digital transformation and business model innovation ($r = 0.403$, $p < 0.010$). Knowledge sharing is positively associated with business model innovation ($r = 0.225$, $p < 0.050$) ($r = 0.225$, $p < 0.05$). The above results lay the foundation for the subsequent regression analysis.

Table 3. Descriptive Statistics and Correlation Matrix for Variables

Variant	A	B	C	D	Enterprise Size	Years of business establishment
Digital Transformation	1. 000					
Business Model Innovation	0.403**	1.000				
Enterprise Product Innovation	0.533**	0.423**	1.000			
Knowledge Sharing	-0.007	0.225*	0.135	1.000		
Enterprise Size	0.040	0.008	0.021	0.019	1.000	
Years of Business Establishment	0.034	0.003	0.073	-0.093	0.038	1.000
Mean Value	3.713	3.806	3.626	3.972	2.590	2.370
Standard Deviation	1.013	0.885	1.073	1.080	0.939	0.853

Note: N=123. A denotes digital transformation; B denotes business model innovation; C denotes enterprise product innovation: D denotes knowledge sharing. * represents $p<0.050$; ** represents $p<0.010$.

4.5. Hypothesis Testing

4.5.1. Direct and Mediating Effects

In this study, the main and mediating effects are tested by using SPSS26.0. First, for the direct and mediating effects, this paper uses PROCESS model 7 to test the results as shown in Table 4-4. First, digital transformation on product innovation is presenting a significant positive effect ($r = 0.533$, $p < 0.01$), with a confidence interval of [0.288, 0.629] at the 95% level, which does not contain 0. Therefore, Hypothesis 1 is supported by the data. Secondly, Table 4 shows that business model innovation plays a mediating role between digital transformation and product innovation with an effect value of 0.158, and then the confidence interval at the high 95% level is [0.049, 0.305], which does not contain 0. Therefore, Hypothesis 4 is supported by the data. Since hypothesis 1 and hypothesis 4 are valid, thus indicating that hypothesis 2 and hypothesis 3 are valid.

Table 4. Direct and Mediating Effects Tests

Path: digital transformation → business model innovation → product innovation						
Effect	Trails	Level	Effect	BootSE	LLCI	ULCI
Direct Effect	Digital Transformation → Product Innovation		0.458	0.086	0.288	0.629
Indirect Effect	Digital transformation → business model innovation → product innovation	Low value	-0.073	0.100	-0.383	0.005
		Median value	0.113	0.046	0.034	0.213
		High value	0.158	0.066	0.049	0.305

4.5.2. Moderating Effects Test

The moderating effect of knowledge sharing was examined by using process model 7 plug-in in SPSS software. According to Table 4-5, by choosing process model 7, the research results show that knowledge sharing plays a positive moderating effect on the relationship between digital transformation and business model innovation. That is, the confidence interval at the high value 95% level is [0.365, 0.685] excluding 0, so hypothesis 5 holds. According to the results shown in Tables 5, the value of the mediated effect that is moderated is 0.091, and the confidence interval at the high 95% level is [0.022, 0.247], excluding 0, so hypothesis 6 is supported by the data.

Table 5. Analysis of Moderated Mediation Effects

Path: digital transformation → business model innovation → product innovation					
Moderator Variable	Level	Effect	BootSE	LLCI	ULCI
Knowledge Sharing	Low value	-0.241	0.1708	-0.5790	0.972
	Median value	0.374	0.067	0.241	0.507
	High value	0.525	0.081	0.365	0.685
Regulated Intermediaries		0.091	0.057	0.022	0.247

5. Conclusion and Discussion

This study examined data from 123 questionnaires and found that, first, digital transformation positively affects corporate product innovation. Second, business model innovation plays a mediating role in digital transformation and enterprise product innovation. Third, knowledge sharing plays a positive moderating role in digital transformation and business model innovation, and the higher the knowledge sharing of the enterprise, the stronger the positive moderating role in digital transformation and business model innovation.

5.1. Theoretical Contribution

First, expanding the research on the outcome variables of digital transformation, existing research for the outcome of digital transformation focuses on the impact on business performance, business development, but neglects the impact on product innovation [33]. As product innovation is conducive to enterprises to continuously meet the needs of consumers, open up new market channels, help enterprises to expand market share and increase the profitability of enterprises. Therefore, product innovation is the key for enterprises to maintain competitiveness and sustainable development in the fiercely competitive market [34]. As a result, this study focuses on the relationship between digital transformation and product innovation in order to form an enrichment and supplementation of existing research on digital outcome variables.

Second, the black box of the relationship between digital transformation and product innovation is opened and the mediating role of business model innovation in it is further investigated. Business model innovation can facilitate the mechanism between digital transformation and product innovation. That is, in this process, the enterprise's business model innovation through the reconfiguration of resources, to open up new market channels to meet customer demand at the same time, to achieve a new value proposition, thus prompting the traditional business digital transformation, product innovation in the new market environment, and ultimately to obtain a competitive advantage in the market.

Third, expanding the study of the boundary conditions for the effect of digital transformation, especially for the new energy automotive industry, knowledge sharing plays an active role in this process. Through the exchange of information and knowledge, knowledge sharing accelerates technological innovation, promotes inter-industry cooperation, and provides important support for product innovation and development in the new energy automobile industry.

5.2. Practical Implications

First, enterprises should actively promote digital transformation, use new technologies, tools and platforms, and encourage employees to participate in digital training, so as to better enhance the level of innovation in product development and market launch. Second, enterprises should innovate their business models according to the changes in the market environment to ensure that they can realize digital transformation. In the process of business model innovation, in order to effectively promote the connection between digital transformation and product innovation, enterprises need to further satisfy customer needs and realize new value propositions. Third, enterprises should focus on the role of knowledge sharing, through the establishment of enterprise social networking platforms and cross-departmental or enterprise collaboration, to enhance the flow of information and improve the ability to innovate.

5.3. Limitation and Future Research

The study has some limitatoins. First, this study uses cross-sectional data collected by the questionnaire survey method, but product innovation of enterprises is a dynamic process, and by conducting a dynamic longitudinal tracking study of digital transformation on product innovation of enterprises, it will further reveal the dynamic impact of business model innovation in the mechanism of the role of digital transformation on product innovation. Secondly, due to the conditions of the research object, the sample is limited to new energy enterprises, so the results are for enterprises in other industries need to be further verified. Future research should range and broaden the adaptability. Once again, the variable measurement tools used in the study are mainly scales developed by foreign scholars, and Chinese enterprises are different from other countries' enterprises, so future research should develop scales of digital transformation, product innovation, business model innovation, and knowledge sharing that meet the needs of Chinese enterprises. Finally, the mechanism of digital transformation on product innovation is not only affected by business model innovation and knowledge sharing, but also by the attitude of top management towards digital transformation, the digital literacy of employees, and the internal organizational culture. In the future, we can study the dynamic impact of potential variables such as digital leadership and employees' digital competence on enterprise product innovation.

Conflict of Interest Statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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