

The Role of IT Applications on New Product Performance in the Digital Age: The Role of Supply Chain Synergy Mediation

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Received: November 13, 2023 Accepted: December 19, 2023 Published: December 31, 2023

doi: 10.5296/ijافر.v13i4.21575

URL: <https://doi.org/10.5296/ijافر.v13i4.21575>

Abstract

Based on resource-based theory, dynamic capability theory and transaction cost theory, this paper analyzes the influence of IT application based on big data analysis on new product performance, the mediating role of supply chain collaboration and the moderating role of relationship risk between supply chain collaboration and new product performance in the context of supply chain collaboration in the digital age. The results show that IT advancement and IT consistency have significant positive effects on new product performance; Joint problem solving and information sharing in supply chain collaboration play a partial mediating role in the relationship between IT advancement and new product performance. At the same time, IT also plays a part of mediating role in the relationship between IT consistency and new product performance. Relationship risk positively moderates the relationship between information sharing and new product performance. The research conclusions not only enrich the existing theories, but also have important reference significance for the digitization and information construction and innovation development in the context of enterprise supply chain collaboration.

Keywords: IT application, Big data, Information sharing, New product performance, Supply chain collaboration

1. Introduction

With the development of digital technologies such as artificial intelligence and big data, all walks of life have accepted a major change, and in the fierce market competition, independent innovation and scientific and technological independence are crucial to the development of enterprises. New product/service development is an important embodiment of enterprise innovation, and enterprises must actively develop new products to maintain or

enhance their competitive position. Under the background of supply chain collaboration in the digital age, new product development has evolved from the traditional independent development of a single enterprise to the joint development activities of all enterprises in the supply chain, which requires the cooperation of all members of the supply chain to complete. In the process of joint development of new products, members of the supply chain need the support of information technology to enhance communication efficiency, jointly solve the problems encountered in the development of new products, and achieve the goal of sustainable operation management.

Under the background of supply chain collaboration in the digital age, new product development increasingly relies on the application of information technology (IT) (hereinafter referred to as: IT application). The main reasons are as follows: First, new product development is an information-intensive business process. Product development task is customer demand-oriented, before developing new products, enterprises need to understand the needs of the target market. IT applications help enterprises fully understand customer needs, so as to develop customer satisfaction product development strategies based on big data analysis. Second, under the background of supply chain collaboration, the joint development of new products needs the support of information technology. The competition between enterprises has evolved from the traditional inventory competition or scale competition to the competition between supply chains. The cooperation of each member in the supply chain is an important factor to maintain the dominant position of the enterprise supply chain. In the process of joint development of new products by supply chain members, IT technology support is needed to enhance communication efficiency and jointly solve problems in development.

In the past few decades, a large number of studies on the IT productivity paradox have emerged, but they are unable to convincingly answer the relationship between information technology investment and enterprise, sector and economic productivity. The shortcomings of existing studies are mainly as follows: First, IT application is a multi-dimensional concept, and the impact of different dimensions on the performance of new products needs to be further explored. A large number of existing studies focus on the role of IT technology in enterprise product innovation, and believe that IT technology application has a positive impact on enterprise innovation ability. However, most studies only make a general study of IT application as a whole concept, and the structural dimension of IT application needs to be improved, and the impact of each dimension on the performance of new products needs to be further discussed. Second, the mediating role of supply chain synergy between IT application and new product performance is not clear. Recent research has highlighted the characteristics of external interactions that produce high innovation performance, and the development of new products requires collaboration with external partners such as suppliers and customers, sharing information, and jointly solving problems in the product development process. Whether different dimensions of supply chain synergy play a mediating role between different dimensions of IT application and new product performance has not been explored. Third, the regulatory effect of relationship risk on the relationship between supply chain collaboration and new product performance needs to be further explored. Relationship risk is

a common problem in business activities. The existence of uneven profit distribution and opportunistic behavior will lead to unstable relationships between enterprises, resulting in adverse consequences. Therefore, whether relationship risk will affect the relationship between supply chain collaboration and new product performance needs further study.

In view of this, based on the extended resource-based view, dynamic capability theory and transaction cost theory, this paper discusses the impact of various dimensions of IT application on the performance of new products under the background of supply chain collaboration in the digital age, and simultaneously tests the mediating effect of supply chain collaboration and the regulating effect of relationship risk. On the one hand, the conclusions of this paper can help Chinese manufacturing enterprises understand the effective deployment of IT technology in new product development; on the other hand, it can provide theoretical and practical basis for the digitization, intelligence, information construction and product innovation development of enterprises.

2. Literature Review and Research Hypothesis

2.1 IT Application and New Product Performance

The resource-based view attributes the improvement of enterprise performance to valuable resources or resource bundles. As a part of the enterprise resource portfolio, information technology may not meet the criteria of resource-based view when it acts alone. The extended resource-based view emphasizes that organizations can manage their own resources not only through internal integration, but also by utilizing the resources of suppliers and customers to create sustainable competitive advantages compared with traditional NPD performance. New product performance (NPP) is more focused on the evaluation of new product development results. From the perspective of measurement indicators, the commonly used indicators of new product performance are: sales growth rate, profit growth rate, market share growth rate, or sales expectation, profit expectation, market share expectation, investment return expectation, etc., which pays more attention to the evaluation of new product development results. Scholars at home and abroad have done a lot of research on information technology and new product performance from different perspectives such as resource-based view, knowledge-based view and organizational innovation, and have obtained rich theoretical results. Applying it to all walks of life has strong practical significance. However, by combing and summarizing the existing relevant literature on IT advancement, IT consistency and new product performance, IT can be found that the direct effect of IT advancement and IT consistency on new product performance needs to be further verified.

Wu *et al.* explored two kinds of IT resources -- IT advancement and IT consistency. Among them, IT advanced nature refers to the extent to which an enterprise adopts advanced information technology; IT consistency refers to the compatibility, connectivity and similarity between the information technology adopted by an enterprise and the information technology of its supply chain collaboration partners. It requires enterprises to consider technology compatibility when developing new products in supply chain collaboration, which can provide a variety of benefits to relevant partners. According to the extended resource-based view theory, IT advancement and IT consistency are two valuable IT resources, which are

conducive to the improvement of supply chain capabilities and can help enterprises achieve good market and financial performance. In the context of supply chain collaboration, new product development within enterprises has evolved into inter-organizational new product development, and companies are going beyond their organizational boundaries to absorb a variety of heterogeneous external resources and enhance their innovation capabilities. Enterprise-level research validates that advanced information technology can help companies gain market share and increase overall productivity. Enterprises using advanced information technology can better respond to market changes and better understand customer needs when introducing new products or services; It can effectively reduce uncertainty, assist managers to formulate price strategies and sales models, help new products successfully enter the market, and obtain expected benefits, and improve market success rate. Similarly, IT alignment among channel members is a source of sustainable competitive advantage. IT consistency improves the functional integrity of communication systems and reduces communication barriers between supply chain partners. The new products of manufacturing enterprises are often composed of millions of parts and developed by hundreds of suppliers, and each enterprise must adopt consistent technology to achieve product integration. IT consistency provides the foundation for this integration, removing potential barriers to incompatibility in cross-company integration. Based on this, this paper proposes the following two hypotheses:

H1: IT advancement has positive influence on new product performance.

H2: IT consistency has a positive impact on new product performance.

2.2 The Mediating Role of Supply Chain Synergy

Based on the research of Simatupang and Sridharan, this paper divides supply chain collaboration into two dimensions, namely joint problem solving and information sharing, and discusses its mediating effect between IT advancement, IT consistency and new product performance. Joint problem solving refers to the cooperation between the manufacturer and the customer in solving the problem and taking responsibility in case of difficulties or unexpected situations. Co-problem solving is a process that involves interactions between a company and its collaborators, often two-way and repetitive. It enables the interacting parties to observe, discover, experiment, prove, and ultimately master knowledge in practice until the problem is solved. Co-problem solving is a capability acquisition mechanism that typically includes problem-solving routines, the adoption of mutually intelligibility terminology, collaborative work schedules, communication mechanisms, and technical teams. This often helps partners avoid negative issues, such as learning contests that turn collaborators into competitors, and facilitates sharing and learning in the long run. According to the dynamic capability theory, the ability of enterprises to control, acquire or organize production resources is different. Therefore, the ability of enterprises to purposefully create, expand or modify their resource base determines the performance of enterprises. Enterprises should not only make full use of internal resources, but also have the ability to access, configure and utilize external data and network resources. Based on this, joint problem solving and information sharing become two effective ways to improve dynamic capability.

Solving problems together is one of the key factors that affect the success of product

development. Working with suppliers and customers to solve the problems encountered in new product development is conducive to product innovation. Extensive knowledge sharing and complementarity will lead to better innovation results, and products created through the participation of suppliers and customers can better meet market needs than products created by enterprises alone. IT advancement and IT consistency provide the basis for common problem solving. Efficient information technology systems enable partners to respond to market changes and customer requests in a timely manner during the development of new products. At the same time, there is evidence that many supply chain collaboration partners have multiple technology platforms, which must be compatible with each other or portable to a unified supply chain management system in order for a single enterprise to collaborate effectively with different supply chain partners. Therefore, this paper proposes the following hypothesis:

H3a: Joint problem solving mediates the positive impact of IT advancement on new product performance.

H3b: Joint problem solving mediates the positive impact of IT consistency on new product performance.

Information sharing is defined as the extent to which an enterprise intends to exchange critical and proprietary information with supply chain synergy partners. Information sharing is the core of supply chain collaboration, supply chain management practitioners need to pay more attention to information sharing. As more information becomes available in the supply chain, partners can change existing plans or develop future plans based on this information. When businesses and external partners share meaningful information about a process, product, or customer, they all benefit. Similar attributes between businesses facilitate communication, and the frequency and intensity of communication has a positive impact on channel outcomes such as coordination, satisfaction, and commitment. The more intensive and frequent the communication between channel members, and the richer the big data shared, the more likely it is to reduce the ambiguity of the information. In a supply chain, many uncertainties are likely to arise due to the lack of information and reliable data about other members. A good example is the bullwhip effect, which is caused by a lack of information symmetry in a distributed system. In the supply chain, information sharing forms a centralized system with less uncertainty, which can significantly reduce or even eliminate the negative effects of bullwhip effect. At the same time, information sharing increases awareness of benefit opportunities and supports joint problem solving. The information exchange between manufacturers and customers and suppliers in the process of new product development enhances the cooperation between enterprises. Information sharing improves the ability to develop new products and services by providing information and knowledge that cannot be obtained within enterprises. With the help of big data analysis tools, we can predict customer needs in a real-time and accurate way, and speed up the decision-making process through data analysis. With participants throughout the supply chain, customer orders, production scheduling, and manufacturing needs become more visible and transparent.

IT advancement and IT consistency based on big data provide a platform for information

sharing. Data is the carrier of information, and advanced and consistent information technology enables supply chain members to share data quickly. IT consistency helps enterprises to integrate information along the supply chain, improve the effectiveness of operational coordination, and then respond quickly to market changes. A good information sharing environment can have a positive impact on supply chain synergy, which facilitates better partnerships and integration between manufacturers and suppliers and customers, leading to better performance. At the same time, the information technology infrastructure provides a platform for information sharing, and the advanced nature and consistency of IT ensure the effectiveness of information sharing. The information sharing of different partners in the process of new product development provides enterprises with external information and knowledge, and improves the innovation ability of enterprises and the performance of new products. At the same time, advanced information technology can facilitate communication between supply chain partners. For example, supply chain systems based on intelligent manufacturing systems involve the most advanced manufacturing technologies, information and communication technologies, and management methods to make timely decisions and accelerate the design, manufacture, production, and delivery of products. With the help of big data analytics tools, customer needs can be predicted in a real-time, more accurate way, and data analytics can be used to speed up the decision-making process. The cloud-based intelligent manufacturing system, equipped with 3D printers, laser cutting and other advanced manufacturing equipment, ensures the rapid manufacturing of highly personalized products to meet customer needs in a timely manner. Therefore, this paper proposes the following hypothesis:

H4a: The positive influence of IT advancement of information sharing intermediary on new product performance.

H4b: The positive effect of IT consistency on new product performance through information sharing intermediaries.

2.3 The Moderating Effect of Relational Risk

In the Chinese context, *guanxi* is defined as a close, universal relationship based on high-quality social interaction and mutual benefit. Relationship is a complex concept that encompasses feelings and feelings for others, trust and reliance, social exchange and reciprocity, and social status. Wiegel and Bamford argue that *guanxi* is a source of competitive advantage, and that *guanxi* can promote business development by connecting personal social relationships with business relationships. The social exchange dimension of relationships provides access to external information and knowledge. Both trust and interpersonal relationships are positively correlated with the amount and credibility of knowledge exchange between buyers and sellers. At the same time, relationships can facilitate the flow of market, process and strategic information when developing and introducing new products.

Miller defines risk as an unexpected and negative change and believes that risk has multiple sources, including internal and external influencing factors. According to this view, risk can be divided into performance risk and relationship risk. Relationship risk refers to the loss of

one partner as a result of the opportunistic behavior of their partner and the possibility of seeking self-interest in their relationship. Relationship risks include those associated with cooperation and those associated with partner behavior. Opportunistic behavior, incapacity, and incomprehension are effective measures of relationship risk. Opportunistic behavior is a kind of behavior that intentionally violates implied or explicit rules in order to pursue one's own interests, including "free rider" behavior and "rip-off" behavior. Loss of capacity and incomprehension measure the risk of uncontrolled disclosure of information in the relationship and lack of understanding between partners, respectively.

During the development of new products, enterprises must protect themselves from the adverse effects of the risky behavior of suppliers or customers. Transaction cost theory points out that market economic entities will incur costs in the process of transaction, including information costs, bargaining costs, default costs, etc. It emphasizes that the core task of enterprises is to effectively coordinate transactions. A firm may seek to maximize its own interests at the expense of those it deals with. Therefore, enterprises will encounter various relationship risks when developing inter-organizational relationship. In the process of new product development, enterprises must consider adopting different control mechanisms to protect themselves from the adverse effects of supplier or customer relationship risk behavior. In the case of high relationship risk, enterprises tend to establish strategic partnerships with other participants to jointly develop new products, and make suppliers or customers become developers of new products through formal (such as contracts) or informal (such as commitments) means, strengthen the degree of information sharing, and jointly solve problems in the development process, so as to improve the performance of new products. Based on the above theoretical analysis, this paper proposes the following hypotheses:

H5a: Relationship risk has a positive moderating effect on the relationship between joint problem solving and new product performance, that is, the higher the relationship risk between cooperative enterprises, the stronger the positive impact of joint problem solving on new product performance.

H5b: Relationship risk has a positive moderating effect on the relationship between information sharing and new product performance, that is, the higher the relationship risk between cooperative enterprises, the stronger the positive impact of information sharing on new product performance.

3. Data Collection and Study Design

3.1 Data Collection and Samples

The data collected by questionnaire survey were collected from five provinces (cities) : Shaanxi, Shandong, Beijing, Guangdong and Jiangsu. Shaanxi, located in the west of China, is a traditional industrial base. Shandong reflects the medium level of China's economic development; Beijing is the center of China's economic decision-making and northern economy; Guangdong is located in the Pearl River Delta, the highest level of economy; Jiangsu is located in the Yangtze River Delta, with a high level of economy and marketization. Therefore, they can represent the various stages and levels of China's economic development.

The data was collected in four phases: in the first phase, 750 companies were randomly selected from a list of companies provided by local governments and business research firms; In the second stage, a telephone consultation was conducted before the formal survey, a total of 246 companies agreed to participate in the survey, and a single contact person was identified with each company, usually a supply chain manager, head of research and development or head of information department, because they have a deep understanding of the company's activities and supply chain management; In the third stage, before the formal questionnaire survey, 10 companies were randomly selected to conduct pilot research, and the variable items and questions were modified according to the feedback of the contacts to improve their accuracy and reliability; In the fourth stage, questionnaires and a letter explaining the objectives of the study and guaranteeing confidentiality were sent to the identified contacts. In order to improve the response rate, the follow-up survey used telephone and email reminders every two weeks. Finally, 214 valid data were obtained by deleting the unavailable data, and the effective response rate was 28.5%. The sample enterprises represent a wide range of industries, involving machinery, metallurgy, electronics and electrical industries, which makes the sample enterprises more representative of China's manufacturing enterprises, and the research results are more universal.

3.2 Questionnaire Design and Variable Measurement

The questionnaire used in this paper is developed on the basis of previous research. First, an English questionnaire suitable for this study was developed. Management researchers proficient in two languages translated the English questionnaire into Chinese, and then re-translated the Chinese version into English. Differences between the translated English version and the original English version were checked and modified repeatedly, and finally a questionnaire suitable for this study was formed. Then, a small scale pre-survey was conducted on the questionnaire. In order to prevent the difficult technical terms in the questionnaire from causing respondents to be unable to answer the situation, the author selected eight enterprises for pre-research, and the data of these companies were excluded from the final data. The questionnaire was further modified based on the feedback from the enterprises to ensure that the content of the questionnaire is easy to understand and appropriate to management practices in China.

3.3 No Response Bias and Homologous Bias Test

The problem of homology bias can arise when two or more variables are collected from the same survey respondents and correlations between them are attempted to be explained. This paper selected two respondents from each of the 10 surveyed companies and then interviewed them separately using the same questionnaire to assess potential single-respondent bias. For practical reasons, these 10 companies were chosen based on their location with the university where I work. Reliability tests show a high degree of internal agreement between the two sets of answers.

4. Research Conclusion and Enlightenment

4.1 Main Research Conclusions

In the fierce market competition, the biggest challenge faced by Chinese manufacturing enterprises is the continuous innovation of products and services. On the one hand, innovation is increasingly dependent on the application of information technology; On the other hand, innovation has changed from the traditional independent innovation of a single enterprise to the joint innovation based on the supply chain. Based on resource-based theory, dynamic capability theory and transaction cost theory, this paper discusses the impact of IT application based on big data (including IT advancement and IT consistency) on new product performance and its mechanism, and introduces the intermediary role of supply chain collaboration and the regulatory role of relationship risk. Through literature research and empirical analysis, this paper verifies the logical relationship among big data-based IT applications, supply chain collaboration and new product performance. Based on the empirical analysis results of 214 valid questionnaires collected from Shaanxi, Shandong, Beijing, Guangdong and Jiangsu provinces, this paper draws the following main conclusions:

1) IT applications based on big data (including IT advancement and IT consistency) help improve new product performance. Successful IT applications should not only pursue the adoption of the most advanced infrastructure, hardware, software, etc., in the supply chain environment, managers need to recognize that consistency is an important factor in the success of IT applications. IT returns are optimized only when managers can effectively coordinate partners' IT investments in supply chain systems.

2) Supply chain synergy (including joint problem solving and information sharing) mediates the relationship between IT applications and new product performance. Empirical analysis shows that joint problem solving and information sharing have a positive impact on new product performance. After controlling intermediary variables for joint problem solving and information sharing, the regression coefficient of IT advancement significantly decreases, and the regression coefficient of IT consistency becomes insignificant from the original significant. This suggests that both joint problem solving and information sharing play a partial mediating role in the relationship between IT advancement and new product performance, and a full mediating role in the relationship between IT consistency and new product performance.

3) Relationship risk has a positive moderating effect on the relationship between information sharing and new product performance. When the relationship risk between cooperative enterprises is higher, the positive impact of information sharing on new product performance is stronger. When enterprises perceive that there is a high risk of relationship with partners, enterprises tend to jointly develop new products with partners, make partners become one of the development subjects, strengthen information sharing, and promote new product development.

4.2 Theoretical Contributions

Based on the above empirical research conclusions, the theoretical contributions of this paper

are shown in the following three aspects: 1). IT enriches the structural dimension of IT applications. When studying the relationship between IT application and performance, most of the existing studies take information technology as a whole resource in general, and pay little attention to the potential different impacts of different dimensions of IT application on performance. This paper subdivides IT application into two dimensions - IT advancement and IT consistency, and verifies their positive impact on new product performance, in which IT advancement has a stronger impact. This conclusion provides a strong theoretical support for enriching the structural dimension of IT applications and expanding the antecedents related to the performance of new products.

2) IT reveals two important dimensions of supply chain collaboration, that is, the mediating role of joint problem solving and information sharing between IT advancement, IT consistency and new product performance. Although the use of information technology is conducive to the development of new products, its internal influence mechanism is not clear enough. This paper verifies that joint problem solving and information sharing play a partial mediating role between IT advancement and new product performance, and a complete mediating role between IT consistency and new product performance, and reveals the mechanism of IT advancement and IT consistency on new product performance. It is helpful to open the "black box" between information technology application and new product performance in the context of digital age and supply chain collaboration.

3) The moderating effect of relational risk on the relationship between information sharing and new product performance is revealed. Most of the existing studies have discussed the causes and negative effects of relational risk, and rarely take relational risk as a situational factor to explore its impact on the relationship between supply chain collaboration and new product performance. This paper takes relational risk as a moderating variable, verifies its positive moderating effect on the relationship between information sharing and new product performance, and enriches the moderating effect of relational risk research.

4.3 Limitations of This Study and Prospects for Future Research

The limitations of this study are as follows: 1). Sample selection: The data used in this study came from manufacturing companies in China, and it is unclear how the selection of other industries and geographic regions will affect the study results. Since product life cycles, competitive environments, and industrial structures are likely to be influenced by countries and industries, future research could further explore the applicability of the conclusions of this study to other industries and geographic regions.

2) Data processing: This study is based on cross-sectional data, and although it has become increasingly challenging and expensive to survey business managers, the data collected from participating managers can provide richer information over time. Future studies may consider using time series data or panel data to test the conclusions of this study.

3) Variable measurement: In terms of measuring the performance of new products, this study uses managers' subjective perception indicators of performance. Future studies can try to integrate objective data to retest the proposed hypothesis.

4) In terms of research content: this study only focuses on the partial mediating role of supply chain collaboration between IT advancement and new product performance. Future studies can continue to enrich the structural dimension of supply chain collaboration or introduce new mediating variables, such as absorptive capacity and knowledge management, for further research.

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