



Research on the Mechanism of Co-production's Impact on Breakthrough Innovations in Chinese Manufacturing Enterprises under the Background of Digital Transformation

Yilin Tian¹, Qiang Li^{1*}, Wei Shi², Ni Lei³

¹School of Economics and Management, Shanghai Technical Institute of Electronics & Information, Shanghai 201411, China

² Shanghai Academy of Social Sciences, Shanghai, 200020, China

³East China Normal University, Shanghai, 200062, China

*corresponding author:liqiang@stiei.edu.cn

Abstract. Amidst the trend of digital transformation and technological paradigm shifts in enterprises, those engaging in breakthrough innovations possess greater market competitiveness, with a higher likelihood of success in the research and development of new products and services, as well as relatively greater profitability. This study aims to construct a theoretical framework by conducting a questionnaire survey among 42 small and micro-enterprises in China's manufacturing sector, involving 410 employees, from December 2023 to April 2024. It seeks to validate how co-production influences enterprises' breakthrough innovation capabilities through three intermediary variables: Knowledge sharing, Learning from Failure, and Job crafting. Furthermore, this study explores how digital capability moderates this influence mechanism. By examining the impact of co-production on breakthrough innovations in small and micro-enterprises, this research endeavors to provide valuable insights for the development of China's manufacturing industry.

Keywords: co-production; Knowledge sharing; Breakthrough innovations; Learning from Failure; job crafting.

1 Introduction

In the current wave of enterprise digital transformation and technological paradigm shifts, fostering collaborative development to promote economic growth, enhance competitiveness, and achieve effective resource allocation, as well as enabling breakthrough innovations in enterprises, are the primary tasks outlined in China's "14th Five-Year Plan and the Long-Range Objectives Through the Year 2035." These have increasingly been recognized as crucial sources for enterprise survival and growth, serving as one of the effective strategies for competition in a dynamic environment. Furthermore, in recent years, co-production, as an emerging collaboration model, has

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garnered significant attention from both academia and practice. Co-production not only provides invaluable user insights but also facilitates the exchange of knowledge and resources, thereby stimulating innovative thinking and practices.

2 Theoretical Hypotheses

The concept of co-production was introduced by Professor Elinor Ostrom in the 1970s, referring to "the integration of regular production and consumer-producer behaviors in public services." Drawing on the research definitions and dimensional frameworks of Wang & Ran (2024), this study categorizes co-production into three dimensions for measurement: knowledge, equity, and interaction. Breakthrough innovations represent significant changes to products or services, offering customers more substantial benefits compared to existing offerings^[1].

During the process of co-production, the close interaction and collaboration between the public and public service providers stimulate innovative thinking and creativity, thereby driving the realization of breakthrough innovations (Jin & Shao, 2022)^[2]. There exists a close link and interaction between co-production and breakthrough innovations. Co-production emphasizes the cooperation between enterprises and external resources, thereby fostering the emergence of breakthrough innovations. Conversely, breakthrough innovations provide robust technical support and motivation for co-production. Based on the above, we propose.

H1: Co-production positively affects an enterprise's breakthrough innovations.

Moreover, although numerous studies have explored various factors influencing enterprise breakthrough innovations, examining how the intermediary variables of knowledge sharing, learning from failure, and job crafting impact the process and outcomes of breakthrough innovations from the perspectives of dynamic capabilities theory and organizational learning theory remains an area worthy of further research. Knowledge sharing is crucial for innovation, with one-third of the new knowledge needed for enterprise innovation originating from external sources. Inter-organizational knowledge sharing helps enterprises acquire external knowledge, breaking internal resource constraints, reducing R&D costs and risks, enhancing innovation efficiency, and avoiding innovation rigidities stemming from a single path, thereby facilitating the recombination of innovation elements and inspiring new innovations or ideas (Turner, et al., 2022)^[3]. Learning from failure can improve entrepreneurs' ability to identify opportunities and acquire resources, further stimulating their entrepreneurial mindset (Ahmed, et al., 2023)^[4]. Leveraging both exploratory and exploitative failure learning methods to analyze, summarize, correct, and optimize failed experiences, as well as reforming and optimizing innovation mechanisms, can enhance the success rate of innovations (Xiao, et al., 2022)^[5]. Job crafting positively affects employee job satisfaction and negatively impacts turnover intentions (Tian, et al., 2022)^[6]. Job crafting positively contributes to employee well-being (Petrou et al., 2012)^[7], which in turn indirectly enhances enterprise innovation. Based on the above, we propose:

H2: Knowledge sharing mediates the impact of co-production on enterprise breakthrough innovations, such that co-production promotes breakthrough innovations by enhancing knowledge sharing behaviors.

H3: Learning from failure mediates the impact of co-production on enterprise breakthrough innovations, such that co-production promotes breakthrough innovations by enhancing failure learning behaviors.

H4: Job crafting mediates the impact of co-production on enterprise breakthrough innovations, such that co-production promotes breakthrough innovations by enhancing job crafting behaviors.

Furthermore, the wave of digital technology sweeping across the globe offers novel solutions to traditional challenges. Digital capability represents the level of innovative application of an organization's digital resources and technologies, benefiting organizations in areas such as management decision-making, information collaboration, business processes, and overall performance, thereby supporting the creation of new value (Andal-Ancion, et al., 2003)^[8]. Digital capabilities with sensing, capturing, integrating, and interacting functions can assist internet enterprises in optimizing knowledge management approaches, enhancing their attack capabilities, and ultimately transforming these into competitive advantages for the entire organization (Arianna, et al., 2021)^[9]. Digital transformation represents a significant shift in the fundamental model of how enterprises create and innovate value (Gong & Ribiere, 2021)^[10]. Digital technologies facilitate scientific decision-making and prompt fundamental transformations in enterprises' innovation models (Yan, et al., 2022)^[11]. Based on these insights, we propose:

H5a: Digital transformation positively moderates the relationship between co-production and enterprise breakthrough innovations.

H5b: Digital transformation positively moderates the relationship between learning from failure and enterprise breakthrough innovations.

H5c: Digital transformation positively moderates the relationship between job crafting and enterprise breakthrough innovations.

H5d: Digital transformation positively moderates the relationship between knowledge sharing and enterprise breakthrough innovations.

In summary, we have constructed a conceptual model examining the factors influencing breakthrough innovations in manufacturing enterprises. For measuring co-production, we utilize the scale developed by Ranjan & Read (2016)^[12], encompassing dimensions of knowledge, equity, and interaction, comprising a total of 12 items. Job crafting is measured using the scale by Bakker, et al. (2012)^[13], consisting of 21 items. Knowledge sharing is assessed with the scale by Jae-Nam Lee (2001)^[14], totaling 7 items. Learning from failure is measured using the scale by Ahmed, et al. (2023)^[4], with 5 items. Digital transformation is evaluated using the measurement items by Vial (2019)^[15], comprising 3 items. Breakthrough innovations are measured using the scale by Chandy & Tellis (1998)^[16], with 4 items. The model illustrates the relationship between co-production and enterprise breakthrough innovations in manufacturing enterprises, as well as the mediating effects of knowledge sharing, learning from failure, and job crafting on this relationship.

3 Research Results

To ensure the representativeness of manufacturing enterprises, this study randomly selected 42 representative enterprises from Beijing, Shanghai, Guangzhou, Zhejiang, Jiangsu, and other regions in China, involving 410 employees from small and micro-enterprises in the manufacturing sector. Data collection was conducted between December 2023 and April 2024, with a total of 410 questionnaires distributed and fully recovered, yielding 368 valid samples.

The questionnaire items used in this research are presented in Table 1. The theoretical model employed in this study has been analyzed using partial least squares structural equation modeling (PLS-SEM) through the Smart PLS 4.0 software.

The results indicate that the Cronbach's alpha values range from 0.807 to 0.973, exceeding the recommended threshold of 0.7. Additionally, the composite reliability (CR) values lie between 0.810 and 0.975, exceeding the threshold of 0.7, and the average variance extracted (AVE) values range from 0.633 to 0.722, exceeding the suggested threshold of 0.5, as proposed by Hair (2009)^[17].

The outcomes of the Fornell-Larcker criterion presented in Table 1 suggest that discriminant validity has been achieved. Consequently, not only are the reliability and convergent validity confirmed in this research, but the discriminant validity is also established (Hair et al., 2012)^[18].

Table 1. Fornell–Larcker criterion.

	I	BI	E	LFF	JC	DT	K	KS
I	0.807							
BI	0.502	0.833						
E	0.484	0.352	0.796					
LFF	0.463	0.591	0.391	0.829				
JC	0.349	0.450	0.151	0.316	0.811			
DT	0.164	0.215	0.248	0.114	0.199	0.849		
K	0.421	0.377	0.298	0.257	0.279	0.108	0.810	
KS	0.310	0.540	0.276	0.462	0.336	0.114	0.271	0.800

Note:K=knowledge;E=equity;I=interaction;KS,knowledge sharing;JC=job crafting;LFF=learning from failure; BI=breakthrough innovations;DT=digital transformation. Co-production is a second-order reflective construct, so no estimation is given here.

The results of the hypothesis testing are presented in Table 2. Co-production ($\beta = 0.047, t = 4.548$) has a positive impact on breakthrough innovations, confirming Hypothesis H1. Job crafting positively mediates the relationship between co-production and enterprise breakthrough innovations ($\beta = 0.030, t = 4.868$), as does learning from failure ($\beta = 0.030, t = 4.868$), and knowledge sharing also positively mediates this relationship ($\beta = 0.024, t = 3.425$), thereby validating Hypotheses H2, H3, and H4. Digital transformation positively moderates the relationships between co-production ($\beta = 0.058, t = 2.134$), learning from failure ($\beta = 0.053, t = 2.059$), job crafting ($\beta = 0.051, t = 2.226$), and enterprise breakthrough innovations, confirming Hypotheses H5a, H5b, and H5c.

Table 2. Path coefficients.

Hy-pothesis	Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STD EV)	Decision
H1	CP -> BI	0.215***	0.222	0.047	4.548	Supported
H2	CP -> JC -> BI	0.058 **	0.060	0.017	3.429	Supported
H3	CP -> LFF -> BI	0.146 ***	0.137	0.030	4.868	Supported
H4	CP -> KS -> BI	0.082 **	0.077	0.024	3.425	Supported
H5a	(CP*DT) -> BI	0.123 *	0.125	0.058	2.134	Supported
H5b	(LFF*DT) -> BI	0.108*	0.113	0.053	2.059	Supported
H5c	(JC*DT) -> BI	0.114 *	0.115	0.051	2.226	Supported
H5d	(KS*DT) -> BI	0.034	0.028	0.059	0.567	No

Note:CP=co-production;KS,knowledge sharing;JC=job crafting;LFF=learning from failure; BI=breakthrough innovations;DT=digital transformation. ***p<0.001;**p<0.01;*p<0.05.

4 Discussion

During the process of co-production, job crafting provides employees with greater autonomy and flexibility, enabling them to leverage their individual strengths and creativity more effectively. The results indicate that job crafting plays a significant mediating role in the impact of co-production on enterprise breakthrough innovations. Through job crafting, employees engage more actively in innovative activities, propose new ideas and suggestions, and drive the implementation and realization of innovation projects. Additionally, job crafting enhances employees' sense of belonging and satisfaction, improving team cohesion and collaboration efficiency, thereby creating a conducive environment and conditions for the emergence of breakthrough innovations. It is recommended to establish knowledge-sharing platforms, organize knowledge-sharing events, foster a culture of tolerance for failure, and establish mechanisms for learning from failure. Furthermore, encouraging employee autonomy and providing diversified work tasks are crucial.

Digital transformation offers more possibilities and choices for employees' job crafting. Leveraging digital tools and platforms, employees can more conveniently adjust work tasks, optimize workflows, and improve work efficiency. The results show that digital transformation positively moderates the relationship between job crafting and enterprise breakthrough innovations. Through digital transformation, employees can flexibly arrange work schedules and locations, select work methods and content suited to their preferences, thereby maximizing their individual strengths and creativity. It is advisable to develop clear digital transformation strategies, strengthen the application of digital technologies, and foster a digital enterprise culture.

5 Conclusion

This study elucidates the mechanism by which co-production influences breakthrough innovations in Chinese manufacturing enterprises within the context of digital transformation. The findings demonstrate that co-production not only directly facilitates breakthrough innovations but also indirectly affects innovation through mediating mechanisms such as knowledge sharing, learning from failure, and job crafting. These results underscore the significance of collaboration between enterprises and external stakeholders, including customers and suppliers.

Notably, digital transformation plays a crucial moderating role in this process. It not only strengthens the direct link between co-production and breakthrough innovations but also amplifies the impact of learning from failure, job crafting, and knowledge sharing on innovation. This suggests that in the digital era, enterprises should proactively embrace digital technologies to fully leverage the innovative potential of co-production.

However, this research also raises several questions worthy of further investigation. For instance, different types of digital technologies (e.g., artificial intelligence, big data analytics, Internet of Things) may exert varying effects on co-production and innovation processes. Furthermore, the interplay between internal factors such as organizational culture and leadership style with digital transformation, and their collective influence on the relationship between co-production and breakthrough innovations, presents a promising avenue for future research.

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