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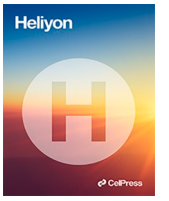

A behavioral model of service-derived manufacturing in e-commerce companies from the innovation chain perspective: A case study from China

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ABSTRACT

In recent years, the business landscape has been reshaped by the fusion of manufacturing and service industries, driven by the "Internet+" initiative and the integration efforts of the Chinese government. This research focuses on the behavior model of service-derived manufacturing within e-commerce enterprises, specifically emphasizing a well-known Chinese enterprise. The study used a case study approach to analyze the manufacturing transformation process. It also reveals insights into the "reverse penetration" model e-commerce service firms adopt. This study aims to help industry practitioners, policymakers, and researchers understand how digital transformation and innovation can enhance manufacturing excellence within e-commerce enterprises. One key aspect examined is the role of e-commerce platforms in connecting manufacturers with consumers, optimizing production through big data analysis, reducing costs, and improving service integration.

1. Introduction

The convergence of manufacturing and service industries, driven by advancements in information technology and changing consumer preferences, has transformed the business landscape. E-commerce Companies are increasingly embracing the concept of service-derivative manufacturing, where products are customized to customer orders and manufactured on demand [1,2]. This paradigm shift has been particularly prominent in the e-commerce sector, where companies leverage innovation chains' power to revolutionize their manufacturing processes and deliver tailored solutions to customers. In the context of this paper, "service--derivative manufacturing" refers to a manufacturing approach within e-commerce enterprises where products are customized and produced on demand in response to specific customer orders. This approach blends manufacturing processes with service-oriented operations, allowing e-commerce platforms to offer personalized products and services to customers efficiently and flexibly, often facilitated by digital technologies and data-driven insights [3]. Thus, the study examines service-derived manufacturing in the Chinese e-commerce platforms, focusing on a prominent enterprise. In today's era characterized by refined industrial division of labor and rapid advancements in information technology, enterprises across various industries have begun embracing the concept of sharing information and resources beyond traditional boundaries. By collaborating with external organizations, enterprises gain access to

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valuable external resources and knowledge, leading to value co-creation by transferring knowledge across organizational boundaries [4]. Increasingly, organizations leverage innovation chains to organize their innovation activities, aiming to achieve enhanced innovation benefits [5,6]. Simultaneously, consumers' aspirations for a high-quality life have transformed their preferences from merely seeking specific physical commodities to embracing comprehensive solutions [7].

Consequently, driven by production resources and market demands, traditional manufacturing and service enterprises have begun exploring cross-border operations, blurring the once-distinct boundaries between industries and giving rise to a novel industrial integration and development model. The integration of the service and manufacturing industries can be observed through two distinct manifestations: manufacturing service and service manufacturing [8,9]. The concept of "manufacturing service" has garnered attention from scholars earlier, referring to the shift of manufacturing enterprises from solely improving products to providing a combination of products and services [8,10]. Service activities have become integrated into the value-creation process of manufacturing enterprises.

Recognizing the significance of service-derived manufacturing and its innovative practices, the Chinese Government has embraced its potential and taken proactive measures to promote its development. In 2015, the Chinese Government introduced the "Internet+" action plan, designed to encourage the integration of mobile Internet, cloud computing, big data, the Internet of Things, and modern manufacturing industries [11]. On November 10, 2019, the National Development and Reform Commission and 14 other departments issued the Implementation Opinions on Promoting the Deep Integration of the Advanced Manufacturing and Modern Service Industry [12]. This document explicitly proposed the concept of "two-industry integration" between the advanced manufacturing and modern service industries, aiming to foster mutual growth and symbiotic coupling. The 14th Five-Year Plan and the 2035 Vision Outline have further emphasized the need to promote the deep integration of the advanced manufacturing industry and modern service industry [12]. With the rapid development of network information technology and the official implementation of the national "Internet+" strategy, service enterprises rooted in Internet technology have begun venturing into the manufacturing field, engaging in a phenomenon known as "service manufacturing" [13–15]. In line with this trend, e-commerce platform enterprises have harnessed selection models, such as Original Design Manufacturing (ODM) or Customer-to-Manufacturer (C2M) approaches, to undergo process reengineering. These enterprises have expanded their service offerings beyond commodity sales to encompass manufacturing capabilities by establishing bidirectional interactive connections between factories and consumers. Noteworthy illustrations of such innovative practices can be found in many leading entities in China.

Considering the dynamics mentioned above, innovation in service manufacturing has garnered scholarly attention and has been put into practice in various industries [14]. This paper adopts an exploratory case study approach, selecting a leading enterprise, a prominent service manufacturing enterprise based in Zhejiang province, as the research sample. However, due to confidentiality agreements and respecting the privacy of the enterprise involved, the researchers have anonymized the case study details to ensure the confidentiality of the company's identity. This study uses an innovation chain analysis framework to investigate the platform service enterprise's manufacturing innovation model from the innovation chain's perspective. Through comprehensive case analysis, the research aims to uncover the potential risks and critical challenges platform service enterprises face during the manufacturing innovation process in China. The findings of this research will enhance our understanding of service manufacturing innovation in e-commerce enterprises and provide valuable policy recommendations for the Government to promote the deep integration of these two industries in China.

2. Literature review

The literature review of this article examines existing research on service derivative manufacturing, innovation chains, and the integration of manufacturing and service industries in the context of e-commerce enterprises, shedding light on the key theoretical foundations and empirical findings in this field.

2.1. Service-derived manufacturing (or service manufacturing)

In recent years, a growing body of literature has focused on service manufacturing in China, driven by the advancement of the "two-industry integration" initiative [16,17]. Service manufacturing involves incorporating modern production methods, standardized products, and management practices into the service industry, increasing the presence of manufacturing elements within the sector [18,19]. Service enterprises transform into manufacturing entities as they develop and scale, entering the manufacturing field with their core technology to produce relevant products. In the context of "Internet +," three modes of service manufacturing have emerged: technology-intensive service-led vertical embedding, capital-intensive service-led horizontal integration, and the "entrepreneur platform" mode [14,15]. These modes can be integrated or give rise to new operational approaches as the "Internet +" concept evolves. Modern service manufacturing is characterized by integration, with the modern service industry taking the lead and incorporating advanced manufacturing technologies and products. This integration allows for providing value-added services to customers, incorporating more manufacturing production elements [20].

The existing literature on service manufacturing has yielded valuable research findings, but theoretical gaps still need to be addressed. While scholars have recognized the increasing integration between manufacturing and service industries, there needs to be more research specifically focused on service manufacturing. More theoretical exploration is needed to understand different dimensions of service manufacturing modes [18,21]. The application of innovation chain theory emphasizes the integration of innovation resources to create value based on market demand. However, empirical case studies are necessary to enhance this theory and offer practical policy recommendations to tackle innovation challenges faced by Chinese e-commerce firms in China. When examining

the specific case of e-services and e-production trading companies, it becomes clear that this process involves innovative activities between multiple service and production units driven by market demand and the integration of industrial chain resources [22,23]. The service innovation chain in Chinese manufacturing requires further exploration and research. This paper aims to address these research gaps through a case study, contributing valuable insights and recommendations for promoting the deep integration of the manufacturing and service industries.

2.2. Innovation and innovation chain

Innovation can be defined as the development of new production capabilities, and the innovation chain represents a systematic sequence of activities [24–27]. The innovation chain focuses on meeting market demand by connecting relevant participants through knowledge-based innovation, aiming to optimize the innovation system and facilitate the economic process of knowledge [26–28]. This chain encompasses various functional activities such as generating new ideas, inventing, designing, and developing new products, creating new production processes, devising new marketing strategies, and expanding into new markets [2,29]. In cross-industry collaboration, the innovation chain extends from upstream to downstream, linking upstream and downstream enterprises in an industrial chain with innovation as the driving force [30–32]. The essence of the innovation chain lies in its market orientation, emphasizing value creation and value addition, involving multiple participants, and aiming to integrate innovation resources. In the era of open innovation, collaborative and innovative efforts among multiple enterprises significantly enhance innovation performance. The application of innovation chain theory has been observed across various industries, including agriculture and the global competition within the integrated circuit industry [33]. Scholars have highlighted the need to extend the construction of innovation chains to encompass all links in industrial ecosystems. Furthermore, China's position in the global innovation chain competition within the integrated circuit industry has been identified as a latecomer, ranking fifth worldwide [32].

Understanding the innovation process in different industries requires knowledge of the innovation chain theory. This theory focuses on the significance of cross-industry collaboration, optimizing innovation systems, and meeting market demands. By adopting this theory, researchers can effectively navigate the complexities of China's ever-changing e-commerce manufacturing industry and contribute to the conversation on innovation excellence. Thus, in this case study, the researchers used the innovation theory to explore service-derived manufacturing in Chinese e-commerce platform companies.

3. Methodology of the research

This section describes the methodology adopted in conducting the case study to analyze the e-commerce service enterprise's "reverse penetration" model. The case study approach allows for an in-depth exploration of real-life scenarios, providing valuable insights and a comprehensive understanding of the phenomenon under investigation.

The selection of the enterprise for the case study for investigating the "reverse penetration" model in e-commerce service enterprises is justified by its remarkable growth, wide product range, and extensive consumer base. The selected company's strategic control of Stock Keeping Units (SKUs) ensures effective information management and product quality. The enterprise's commitment to continuous improvement is evident through its independent production lines, joint Research and Development (R&D) laboratories, and digital smart supply chain system, which contribute to production capacity, R&D capabilities, and understanding of consumer demands. As an integral part of innovation business, the enterprise's noteworthy financial performance and recognition by central and local governments validate its role in empowering the physical manufacturing industry. The company's industry impact is highlighted by its inclusion in national initiatives, such as the "Made in China" brand work plan and recognition as an industrial Internet pilot demonstration project. The enterprise's achievements have garnered prestigious accolades, including Forbes' Top 50 Most Innovative Enterprises in China and the China Design Intelligent Manufacturing Award. With its significant market presence, integration of manufacturing and innovation, government and industry recognition, and notable achievements, the enterprise emerges as an ideal case study for exploring the "reverse penetration" model in e-commerce service enterprises.

The case study approach is being used for this research to explore the "reverse penetration" model in e-commerce service enterprises, and this approach enables a contextual understanding of the unique factors and dynamics involved in implementing this model [34,35]. Case studies provide practical insights into the challenges, outcomes, and complexities of the "reverse penetration" model and collect diverse data from multiple sources, enabling a comprehensive topic exploration [33,34]. Furthermore, it allows for a holistic perspective, examining various dimensions such as organizational strategies, operational processes, innovation mechanisms, and stakeholder impact.

Additionally, the case study approach offers opportunities for theory-building by generating new insights, proposing hypotheses, or refining existing theories based on real-life data analysis. Considering these advantages, the researchers used the case study approach as an appropriate methodology.

3.1. Data collection process

The data collection process for this case study employed multiple methods to gather comprehensive and in-depth insights. Primary data was collected through interviews with key stakeholders within the sample enterprise, including managers, employees, and other relevant individuals who possess valuable knowledge of the organization's operations and strategies.

During the field visits, the researchers interviewed a diverse group of participants, encompassing top-level executives, including the CEO, four key personnel from the sample company, and three middle-management representatives from each manufacturing company.

The researchers engaged with two female executives in top management positions at the sample company and interviewed one female middle manager who actively contributed to the manufacturing companies. On average, these interviews took one to one and a half hours to complete. This comprehensive and diverse selection of participants provided us with a wealth of perspectives and insights that are highly pertinent to the study. The field visits were completed between September and December 2022.

Additionally, supplementary data was obtained through observations and document analysis, further enriching the dataset. The combination of these data collection methods allowed for a holistic understanding of the case study, ensuring the robustness and reliability of the gathered information. The data collected from the above source provided insights into the "reverse penetration" model's operational aspects and strategies. This approach allowed a profound exploration of the intricate dynamics and mechanisms underlying service-derived manufacturing in e-commerce enterprises.

Special attention was given to designing the interview process, acknowledging the importance of the interviewer-interviewee relationship in qualitative research [36–38]. The interviews commenced with an introductory phase, during which participants shared relevant background information. Subsequently, the interviews were structured to elicit insights into participants' motivations, objectives, and definitions of success within the context of service-derived manufacturing in e-commerce enterprises. The interviews were semi-structured, allowing for a flexible yet focused exploration of the participants' perspectives, experiences, and insights regarding the implementation of the "reverse penetration" model. These interviews captured a range of relevant topics, such as the decision-making process, challenges encountered, strategies employed, and outcomes achieved. Valuable firsthand information was obtained, providing a deeper understanding of the operational aspects, innovations, and collaborations in the "reverse penetration" model. In addition to primary data collection, data from internal documents, reports, and industry publications were collected. Internal documents, such as company reports, memos, and policy documents, provided information on the organizational structure, goals, and strategies. Reports and publications offered broader industry perspectives, market trends, and best practices relevant to the "reverse penetration" model. These secondary data sources enriched the analysis and provided a comprehensive overview of the research subject. Combining primary and secondary data sources ensured a robust and comprehensive data collection process. The primary data obtained through interviews offered unique and contextual insights specific to the enterprise, while the secondary data provided a broader industry context and corroborated the findings. This multi-method approach aimed to capture diverse perspectives and triangulate the data to enhance the validity and reliability of the study's findings. In order to maintain data quality, rigorous data management procedures were followed. This included accurate transcription and documentation of interview responses, careful organization and storage of documents and reports, and adherence to ethical considerations regarding data confidentiality and anonymity. The case study was conducted until data saturation occurred, signifying that no new insights or perspectives emerged from the interviews, a widely recognized approach in qualitative research [39,40].

3.2. Data analysis techniques

The researchers organized and classified the collected data into relevant categories for systematic analysis. The researchers manually analyzed the data through coding to reveal vital insights and findings related to our sample enterprise's 'reverse penetration' model. The data analysis involved identifying patterns and themes by assigning labels to different data segments, such as interview transcripts and document excerpts. This approach ensured a thorough data exploration and facilitated the identification of key insights and findings [41]. The analysis revealed that coding during the data collection phase of case studies helped maintain the authenticity of the participants' voices, making it a highly advantageous method. Memoing was used as a data analysis technique to record reflective notes and interpretations during the analysis process. Memoing helped researchers capture their thoughts, insights, and interpretations as they reviewed the data [42]. It was crucial in fostering critical thinking and documenting the researchers' thought process and analytical journey, ensuring transparency and traceability in the data analysis process. Reflective notes and interpretations maintained an audit trail of analytical decisions, supporting the development of robust arguments and conclusions. Memoing also encouraged reflexivity, enabling researchers to critically engage with the data and refine their understanding of the "reverse penetration" model in the case of the sample enterprise.

Using multiple sources helped confirm findings, validate interpretations, and boost the study's reliability. Member checking was conducted to validate the accuracy of the collected data and enhance its credibility. The preliminary findings were shared with the enterprise stakeholders through WeChat and emails, allowing them to review and validate their contributions. WeChat and email served as convenient and accessible means for participants to evaluate the research findings, offer feedback and contribute to the validation process. Researchers implemented a data validation process throughout our research to ensure that the data we collected was accurate and reliable. The study took measures to confirm the accuracy and authenticity of the information obtained from interviews and other sources. Researchers consulted with experts in e-commerce and service-derived manufacturing to validate our findings. These measures ensured a thorough and systematic examination of the data, contributing to the study's rigor and reliability.

4. Results

The study comprehensively analyzes three distinct case studies within the e-commerce platform industry. Through an in-depth case study analysis, this research explores the service-derived manufacturing model of e-commerce enterprises from the perspective of the innovation chain. The findings shed light on the intricate dynamics and critical factors that contribute to the success of this model, offering valuable insights for practitioners, researchers, and policymakers in the e-commerce industry.

4.1. Introduction to the chosen case study enterprise

This e-commerce platform, established in late 2015, is a well-known and reputable brand that provides consumers with high-quality and affordable products. The enterprise was first established as an e-commerce platform, and its main focus was selecting various manufacturers and products aligned with its overall style and requirements. The company did not take part in product design or production or invest in any factories. Instead, they partnered with manufacturing firms to create and produce their products. The company carefully selects products that meet its standards from the manufacturing firms' offerings and sells them under its brand on its e-commerce platform. In subsequent years, the enterprise expanded its presence in manufacturing, gradually participating in product design and production processes. The enterprise boasts a team of nearly 100 professional designers and collaborates with over 400 excellent design companies, attracting talents from Denmark, Italy, Japan, and South Korea. In recent years, the "Innovation Open Platform" launch further enhanced the enterprise's capabilities by integrating global design, manufacturing, and educational resources. This platform focuses on discovering and nurturing original products in response to evolving consumer demands. Through innovative initiatives, the enterprise has successfully introduced more than 20 original design series and around 140 image products. These details form the foundation for analyzing and comprehending this renowned company's 'reverse penetration' model.

4.2. Collaborations with manufacturing companies

Through strategic collaborations with manufacturing enterprises, the sample enterprise has showcased its ability to transform products, enhance user experiences, and achieve remarkable market success. This section highlights three exemplary cases that exemplify the enterprise's commitment to innovation and customer-centricity.

4.2.1. Collaboration with a famous weaving company

One prominent example of service-derived manufacturing within the enterprise is a weaving company. This weaving company faced challenges arising from a decline in foreign trade and sought to shift its focus toward domestic sales with the help of the sample enterprise. However, lacking sufficient knowledge and understanding of the Chinese domestic market, the weaving company encountered significant difficulties during its initial attempts to penetrate the domestic market. One significant challenge was the inability to meet market demands on time, leading to products like baseball uniforms becoming outdated soon after launch. As a result, the weaving company incurred substantial losses, estimated at approximately Chinese Yuan one million within a single month.

Mid-2018 an important development occurred as the weaving company transitioned into an upstream supplier for the sample enterprise. During this collaboration, the sample enterprise shared consumer data insights and demands for woolen and knitted sweaters accumulated on their platform with the weaving company. In response, many consumers expressed their desire for woolen sweaters that could be conveniently machine-washed, highlighting a specific market need. In response to this demand, the enterprise's R&D team joined the weaving company's team, embarking on a collaborative design and development process that spanned approximately three months. The outcome of this joint effort was the successful creation of machine-washable woolen sweaters. Upon their release, these sweaters garnered an overwhelmingly positive response, boasting an impressive approval rate of nearly 99.6 % on the enterprise platform. Introducing these innovative and consumer-friendly woolen sweaters also had a notable impact on the overall sales performance of the woolen sweater category on the platform, fueling a remarkable growth surge of more than 20 %.

4.2.2. Collaboration with a famous wine company

In collaboration with a famous wine company, the enterprise successfully targeted a younger consumer group for yellow wine, which was initially popular among older individuals. The enterprise positively transformed the brand image by creating a higher-end yellow wine that appealed to and resonated with the younger demographic. Firstly, the enterprise redesigned the product's outer packaging to make the "wine bottle" look more modern and trendier. Consumers praised this modification, mentioning that the bottle could be repurposed as a beautiful flower vase. Moreover, the original yellow wine had a robust flavor in terms of taste. The enterprise actively engaged in personalized customization by incorporating additional ingredients. This transformation retained the essence of yellow wine while delivering a more refreshing, smooth, and subtly sweet taste. Consumers even left comments indicating that they experienced no hangover effects. With a remarkable approval rate of 99.4 % on the platform, this yellow wine garnered over 50,000 orders, signaling its tremendous success in the market.

4.2.3. Collaboration with a famous furniture company

The sample company has recognized the increasing popularity of furniture among customers and has strategically partnered with a famous traditional Chinese furniture company. Later, the sample company assisted the furniture company in designing an online feedback system. The furniture company gained popularity in the Chinese market due to its fashionable and lightweight design, surpassing other furniture companies after the strategic collaboration. Over the subsequent years, the furniture company diligently monitored user feedback by utilizing the sample enterprise computer terminal. This is an intricate tool developed to facilitate product iteration and selection. Based on this continuous feedback loop, the design of the furniture company's chair underwent adjustments to ensure optimal user experience. Upon the initial launch of the furniture company chair, users provided valuable feedback primarily focused on two aspects. Firstly, they highlighted that the size of the chair was relatively large for Chinese individuals, leading to discomfort during use. Additionally, female users expressed difficulty adjusting their inclinations. In response, the enterprise embarked on an iterative process to enhance sitting comfort. By attentively listening to user feedback and incorporating necessary modifications, the enterprise demonstrated its commitment to delivering a chair that met the needs and preferences of its customers.

The enterprise chair underwent 15 iterations, producing a highly refined and popular product. It gained significant recognition when selected as the sales item for one live broadcast channel in China, selling out more than 5000 sets in seconds. In a shopping festival, the chair secured the second position in the self-operated computer chair category. These achievements highlight the enterprise 's dedication to continuous improvement and customer satisfaction, establishing the furniture company chairs as a sought-after product.

These examples highlight the enterprise's ability to transform traditional manufacturing processes, deliver innovative products, and maintain a customer-centric approach. The enterprise's service-derived manufacturing model highlights its agility, adaptability, and commitment to delivering high-quality products in the e-commerce industry.

4.3. Exploring the enterprise service manufacturing mode through an innovation chain perspective in China

The manufacturing process of e-commerce service enterprises can be analyzed as an innovation chain driven by market demand and integrating industrial chain resources in China. The innovation chain of e-commerce platform enterprises can be divided into several key links [43,44].

The first link is the information collection or creative stimulation link. Through search records and consumer evaluations on the platform, e-commerce enterprises gather valuable data reflecting consumer purchase demands and product improvement suggestions. The second link is the research and development link. Based on the ideas obtained from the information collection link, e-commerce platforms, and manufacturing enterprises collaborate in research and development activities. This involves enhancing the technical performance of existing products or developing entirely new products [2]. The third link is the trial improvement link. Manufacturing enterprises produce new products in small batches, which undergo various performance tests. The fourth link is the mass production link, where the newly developed products are officially put into production. The fifth link is the market sales link. The new products are sold through the e-commerce platform, and both manufacturing and e-commerce enterprises reap the benefits of innovation. However, according to the results of the case study, Chinese service-based manufacturing has important innovative features. The sample enterprise and the strategic collaboration with manufacturing firms give insight into these innovative approaches.

Fig. 1, "The Innovation Chain of Service-Derived Manufacturing in E-commerce Enterprises," visually represents the interconnected stages of service-derived manufacturing. It illustrates the flow of activities from product design to material procurement, production, and quality inspection. The figure is a valuable reference for understanding the comprehensive nature of service-derived manufacturing in e-commerce enterprises in China. It highlights the importance of integrating feedback from big data and the backend supply chain to assess risks, establish acceptance standards, and implement robust product traceability systems. Unlike typical innovation chains that initiate from knowledge innovation in scientific research institutions, the e-commerce platform leverages data, technology, capital, and other innovation resources to drive the functioning of the entire chain. This enables the e-commerce platform and manufacturing enterprises to achieve an optimized value-creation process together in the Chinese context.

Turkenburg, in 2000, proposed two innovation chain models: forward linear and reverse feedback [45]. The forward model emphasizes the one-way flow from research to marketization, while the reverse feedback model enables information exchange between different chain stages. However, the analysis of the Chinese enterprise case study shows that essential innovations are occurring in manufacturing e-commerce services using a reverse feedback model. In this model, the platform enterprise collects market data, shares it with upstream manufacturing partners, and integrates it into the R&D process for marketization [25,46]. A proactive approach to quality, starting from the initial design stage, is key to consistent, high-quality products rather than relying solely on end-of-process inspections [4]. In the e-commerce industry chain, manufacturing enterprises and e-commerce platforms operate as upstream and downstream entities in China. E-commerce platforms utilize Internet big data to integrate information resources and extend their reach into manufacturing, creating a "reverse" innovation process. E-commerce service enterprises engage in "reverse penetration" by investing in, collaborating on, and leading innovation in manufacturing production [47,48]. This intervention spans various stages, including product design, material procurement, production, and quality inspection. The case study highlighted that e-commerce service enterprises contribute to risk assessment, formulation of acceptability standards, and establishment of product traceability systems by incorporating feedback from big data and the backend supply chain in China.

Fig. 2, the "Reverse Penetration Model by E-commerce Service Enterprises," depicts Chinese enterprises' unique approach to achieving manufacturing innovation. It showcases the feedback loop between the e-commerce service enterprises and the backend supply chain, emphasizing the utilization of data-driven insights for risk assessment, acceptance standard formulation, and product traceability. This process plays a crucial role in constructing a high-quality manufacturing industry chain, aligning with Chesbrough's notion that quality must be integrated from the design stage to achieve consistent, high-quality, and reliable products [5,7,44].

The above two figures serve as visual aids to enhance the understanding and communication of the research findings. The

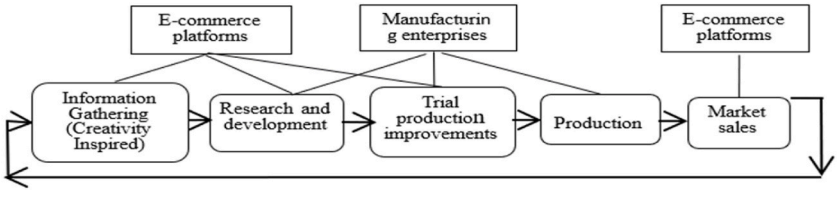

Fig. 1. The innovation chain of service-derived manufacturing in E-commerce enterprises in China
Source: Author compiled.

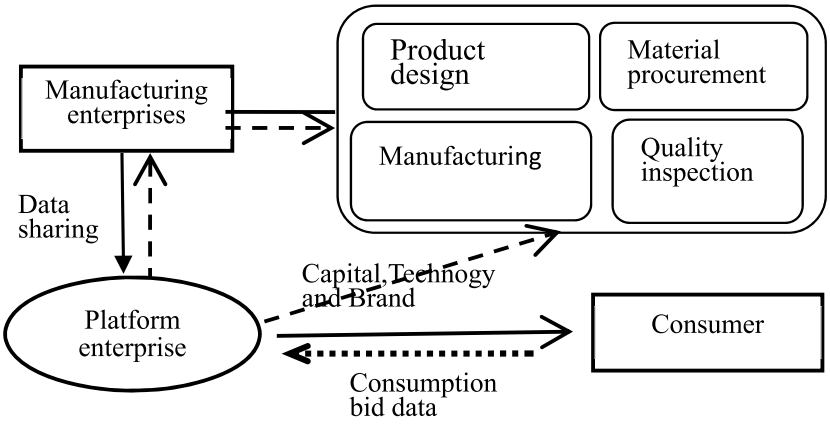

Fig. 2. Reverse Penetration Model by e-commerce service enterprises in China.
Source: Author Compiled.

innovation chain and the reverse penetration model presented in the figures underscore the importance of collaboration, information sharing, and the utilization of data analytics in driving manufacturing innovation in China.

After presenting the results, it is crucial to have a meaningful discussion about the implications of the findings. This section allows researchers to explore the dynamics of service-derived manufacturing in e-commerce enterprises in China.

5. Discussion

In exploring the complex world of service manufacturing innovation in China, the study discovers many valuable insights and implications that highlight the transformative power of this dynamic industry. Through this discussion, researchers uncover the main findings, shed light on the implications, and navigate the results of our analysis, providing a deeper understanding of the changing landscape of service manufacturing in the digital age.

The study uncovers the interplay between service provision and manufacturing processes, demonstrating the transformative potential of integrating services and manufacturing in the digital landscape. While China boasts numerous high-quality manufacturers, these enterprises encounter many challenges. These include the persistent threat of price reductions by foreign brands, the fierce competition that sometimes leads to order loss, and the mounting labor costs that have prompted some manufacturers to relocate their production bases abroad [49]. On the other hand, some manufacturers receive support from e-commerce platforms to innovate their products and tackle challenges, resulting in greater success in the Chinese context. In light of the Upstream Industry Demand for Innovation in China's Manufacturing Sector and the intensified competition within the e-commerce industry in China, both e-commerce platform enterprises and manufacturing companies actively pursue strategic collaborations.

a. Upstream Industry Demand for Innovation in the Manufacturing Sector in China

With the recent decline in foreign demand, it has become crucial for Chinese manufacturing, particularly in the consumer goods sector, to tap into the domestic market. However, manufacturing factories often need to understand consumer needs and market dynamics, leading to inefficient production supply chains and slow responsiveness to market changes. In this context, e-commerce platform enterprises can bridge the gap by leveraging their service capabilities to connect manufacturing enterprises with market demand [23,46]. E-commerce platform service enterprises can dynamically assess domestic consumer preferences and demand through big data analysis. This enables manufacturing enterprises to use customized production, efficient procurement, planning, and logistics management [25,50]. This collaboration helps improve inventory turnover, reduce costs, and enhance energy utilization rates, ultimately facilitating the integration of manufacturing and service sectors in response to evolving market environments.

b. Market competition in the e-commerce industry in China

Market competition in the e-commerce industry is also intensifying due to the widespread adoption of the Internet and intelligent technology. The saturation of user scale and market penetration rates has led to a slowdown in industry growth. Innovation and efficiency improvements within the existing market scale are crucial to maintaining competitiveness [51]. Various new models have emerged in the retail e-commerce sector, including social group buying, live e-commerce, micro-business distribution, and selection e-commerce. These models have brought sales growth through innovative sales approaches but have yet to substantially change the connection between e-commerce platforms, manufacturers, and consumers along the industrial chain [52]. In this competitive landscape, selection e-commerce has emerged as a distinct model that establishes a two-way interactive connection between upstream manufacturers and terminal consumers. This model even directly participates in the manufacturing process, exemplifying the concept

of "service manufacturing" within the industry in China. This collaboration proves instrumental in fostering a mutually beneficial, win-win scenario for both enterprises. The Strategic alliances between the two sectors showcase its ability to leverage consumer insights, collaborate with manufacturing enterprises, and drive product evolution through an innovation chain framework.

c. Lean Manufacturing Enabled by Big Data Analysis

One noteworthy aspect of the enterprise's service manufacturing innovation is its utilization of big data analysis to facilitate lean manufacturing practices. Recognizing the challenge manufacturing enterprises face in directly perceiving market demand, e-commerce platforms like the sample enterprise serve as product distributors and leverage consumer big data and feedback to enhance collaboration with manufacturing partners. This enables manufacturing enterprises to gain faster market insights, optimize production processes, and better cater to consumer needs. The partnership between the enterprise and the weaving company exemplifies this approach.

The collaboration between the enterprise and the weaving company exemplifies the power of big data analysis in driving lean manufacturing practices, facilitating on-demand flexible production, and ultimately meeting consumer needs effectively.

d. Support and Investment in Manufacturing Enterprises - Enhancing Research, Design, and Recovery

The enterprise's service manufacturing innovation extends beyond mere collaboration with manufacturing enterprises. It actively supports and invests in these enterprises to foster their development and enhance their capabilities. By deploying research and development teams to participate in manufacturing partners' research and design processes, e-commerce platforms provide crucial "software" support, contributing to product innovation and improvement. Furthermore, the enterprise's investments in manufacturing enterprises aim to enhance their production lines, ensuring they have the necessary "hardware" resources to meet the demands of product updating and upgrading.

The outbreak of the pandemic dealt a severe blow to manufacturing enterprises. In response, the enterprise established a special procurement fund and implemented a unique payment method that allowed manufacturers to receive payment first and deliver goods later. This flexible approach provided much-needed financial support to struggling enterprises, aiding their recovery from the recessionary impacts of the pandemic. By combining financial assistance, research and design collaboration, and investment initiatives, the enterprise demonstrates its commitment to empowering manufacturing enterprises, fostering their growth, and supporting their resilience in challenging times.

e. Guiding Manufacturing through Brand Authorization - Expanding the Manufacturing Link

In addition to collaborating with manufacturing enterprises, e-commerce platforms like the sample enterprise can extend their influence into the manufacturing link by leveraging the products these enterprises provide. By analyzing consumer big data and utilizing their advantages in areas such as big data, technology, channels, and creativity, e-commerce platforms can trace back from the consumer side and delve deeper into the manufacturing process through entrustment manufacturing and brand authorization [51]. This approach enables platforms to guide manufacturers in producing and developing service-derived manufacturing.

Platform enterprises offer significant benefits, particularly for small and medium-sized manufacturing enterprises. By partnering with platform enterprises, these manufacturers can save valuable time and capital that would otherwise be required to build their own brands. Through brand authorization and deepening collaboration with manufacturing enterprises, e-commerce platforms like the enterprise unlock new opportunities for product diversification and expansion, allowing manufacturers to tap into the platform's vast consumer base and innovative potential. This symbiotic relationship between platform enterprises and manufacturing partners enables both parties to leverage their strengths, driving growth and delivering unique and desirable products to consumers.

f. Promoting the Transformation of Flexible Supply Chain - Shortening Production and Sales Links

The enterprise is committed to promoting the transformation of the flexible supply chain and actively invests 200–300 million Chinese Yuan annually in platform and supply chain research. In order to facilitate the launch of new products or enhance existing product features, the enterprise employs strategies such as small orders with fast returns or crowdfunding modules to gauge market response. By adopting these approaches, the enterprise provides manufacturing enterprises with increased production and delivery adjustment flexibility.

E-commerce platforms like the enterprise go beyond their role in product display and sales. They also strive to establish flexible and open supply chain systems, leveraging the comparative advantages of each node in the supply chain. This approach enables faster product delivery, improved product quality, and reduced costs, ultimately shortening the production and sales links. The enterprise empowers manufacturers to respond swiftly to changing market demands by building a flexible and efficient supply chain. This is achieved through small-scale, agile production methods and dynamic product testing. As a result, manufacturing enterprises can adapt their production and delivery processes, ensuring faster delivery to consumers while maintaining high-quality standards.

The service manufacturing innovation of the enterprise showcases the platform's ability to harness consumer insights, collaborate with manufacturing enterprises, and drive product evolution through an innovation chain perspective. The enterprise enables lean manufacturing practices by leveraging big data analysis, empowering manufacturing partners like weaving companies to optimize production and better meet consumer needs. The enterprise's support and investment in manufacturing enterprises also foster

research, design, and recovery efforts, strengthening their capabilities and resilience.

Platform enterprises can create a more conducive environment for manufacturing innovation by addressing the challenge of flexible order-taking. Collaborative efforts and mutually beneficial agreements enable manufacturing enterprises to leverage the advantages of the e-commerce service model, including faster market testing and improved responsiveness to consumer demands [26, 53]. In considering the evolving landscape of manufacturing and services, it is noteworthy to acknowledge the parallel phenomenon of servitization, wherein traditional manufacturing industries increasingly integrate services into their offerings [54–56]. While our study primarily focuses on the 'Reverse Penetration' model in e-commerce enterprises, the coexistence of servitization underscores the multifaceted interplay between manufacturing and services in the contemporary business environment. The research findings contribute to a better understanding of service manufacturing innovation in e-commerce in China. Collaboration with manufacturing enterprises and e-commerce platforms can expand market reach, increase innovation, and improve customer service in China.

6. Conclusions, limitations, and future directions

In conclusion, this study demonstrates that the selected platform service enterprise follows a unique " Reverse Penetration innovation chain. The enterprise plays a pivotal role as an innovation driver, leveraging data sharing, capital and technology input, and brand authorization to propel the development of the service-to-manufacturing industry. Through its proactive engagement, platform service enterprise contributes to transforming and integrating services and manufacturing, fostering innovation and growth in the Chinese market. The insights gained from this research offer valuable implications for policymakers, industry practitioners, and researchers seeking to navigate and capitalize on the evolving landscape of manufacturing in platform service enterprises. However, challenges such as capital investment risks, scarcity of technical personnel, and fractures in the innovation chain hinder manufacturing innovation in platform enterprises in China. This study represents an initial exploration of the intricate interplay between service and manufacturing within a specific e-commerce enterprise in the Chinese market. It underscores the paramount significance of digital transformation and innovation for businesses striving for success in China's dynamic business landscape.

Although this paper has revealed the obstacles and constraints that hinder manufacturing innovation in platform enterprises, it is important to acknowledge a few limitations. Firstly, the research primarily focused on the perspective of e-commerce service enterprises, and the findings may need to fully capture the complexities faced by other types of platform enterprises. Secondly, the study is based on a single e-commerce enterprise in the Chinese market. Findings may not be universally applicable to different industries or regions. Caution is advised when extending these results beyond similar contexts. A broader range of enterprises and contexts is needed to assess generalizability. The study data collection methods may have biases, and the research represents a snapshot of the industry at a specific time. Additionally, the study mainly concentrated on the specific context of the enterprise, which may limit the generalizability of the conclusions. Future studies should address these limitations and provide a more comprehensive understanding of manufacturing innovation in platform enterprises.

There are several avenues for future research in the field of manufacturing innovation in platform enterprises. Firstly, additional research could explore the role of technological advancements, such as artificial intelligence, blockchain, and the Internet of Things, in facilitating and accelerating manufacturing innovation. Understanding how platform enterprises can effectively leverage these technologies can offer valuable insights for both academia and industry. Moreover, investigating the impact of regulatory frameworks and policies on manufacturing innovation in platform enterprises would be worthwhile. Analyzing the challenges and opportunities arising from government regulations can guide policymakers and help foster a supportive environment for innovation and collaboration between service and manufacturing sectors. Comparative studies examining multiple platform enterprises operating in diverse industries and regions can offer a broader perspective on the challenges and solutions associated with manufacturing innovation. Researchers can identify common patterns, industry-specific factors, and best practices contributing to successful manufacturing innovation in platform enterprises by conducting cross-industry and cross-regional analyses. Lastly, longitudinal studies tracking the evolution and development of manufacturing innovation in platform enterprises over an extended period can offer valuable insights into such innovations' long-term sustainability and impact. Further studies are needed to capture and identify emerging trends, challenges, and opportunities that may arise as platform enterprises continue to shape the manufacturing landscape. Also, in future research, it is essential to explore the phenomenon of servitization alongside 'Reverse Penetration' to comprehensively understand the evolving relationships between manufacturing and services in platform enterprises. Future research should address these gaps and contribute to a comprehensive understanding of manufacturing innovation in platform enterprises, enabling policymakers, industry practitioners, and academics to make informed decisions and drive sustainable growth in the manufacturing industry.

CRediT authorship contribution statement

Yang Li: Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **P.J. Kumarasinghe:** Writing – review & editing, Validation, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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