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The Alignment Between Digital Servitization Strategies and Digital Servitization Capabilities in Chinese Manufacturing Enterprises: A Multi-Case Study

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Abstract

Grounded in the dynamic capability theory, this study selects three typical manufacturing enterprises as the research subjects. Through longitudinal and cross-case analyses, it delves into the dynamic alignment between the digital servitization capabilities and strategies of manufacturing enterprises, as well as the mechanism through which this alignment influences firm performance. The findings indicate that—within the framework of capabilities, such as the strategy alignment model—among six potential alignment scenarios, only three configurations exert a significantly positive impact on firm performance: the alignment of service data integration capabilities/service demand exploration capabilities with product-centric digital servitization strategies and the alignment of digital service orchestration capabilities with ecosystem-centric strategies. The former bolsters efficiency advantages through value-added product servitization, while the latter unlocks ecological dividends by capitalizing on network effects. By uncovering the stage-specific patterns of capability–strategy alignment, this study enriches the dynamic capability theory with a micro-level explanation in the context of digital servitization. It also offers a staged transformation roadmap for manufacturing enterprises to mitigate the risk of misalignment between strategic choices and their existing capabilities.

Keywords: digital servitization strategy; digital servitization capabilities; alignment; performance

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Academic Editor: Zongjun Wang

Received: 2 July 2025
Revised: 7 August 2025
Accepted: 14 August 2025
Published: 18 August 2025

Citation: Zhang, L.; Chen, J.; Dong, H. The Alignment Between Digital Servitization Strategies and Digital Servitization Capabilities in Chinese Manufacturing Enterprises: A Multi-Case Study. *Systems* **2025**, *13*, 707. https://doi.org/10.3390/systems13080707

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1. Introduction

Manufacturing is a cornerstone of the national economy. Against the backdrop of the fading demographic dividend and highly individualized customer demands, traditional manufacturing enterprises are confronted with the dual challenges of rising service costs and shrinking profit margins [1]. To address this predicament, "Made in China 2025" has listed service-oriented manufacturing as a strategic priority, calling on enterprises to actively leverage new-generation information technologies to empower new manufacturing methods and foster new services. The digitalization of manufacturing services has become a core driver for enterprises to gain competitive advantages [2]. For instance, Xi'an Shaangu Power Co., Ltd. (SG) (Xi'an, China) has enhanced efficiency through remote monitoring services. Otis Elevator has achieved a service profit share of 79% thanks to its digital platform, and the Digital Industries division of Siemens contributes 38% of its operating profit. However, many enterprises have failed to achieve the expected returns. For example,

GE's digital business transformation was hindered by high-cost customized investments, and some enterprises have fallen into a "digital trap" due to ongoing technology updates and operation and maintenance costs (such as overspending caused by regular sensor upgrades) [3]. This contradiction highlights a core issue: manufacturing enterprises urgently need to build their digital service capabilities and select matching digital service strategies to break the "high investment, low return" transformation deadlock.

In recent years, the academic community has drawn attention to the integration of digitalization and servitization (i.e., "digital servitization") [4] and emphasized the pivotal role of the alignment between digital servitization capabilities and strategies [5]. The dynamic capabilities paradigm [6], the strategic fit paradigm [7], and the service-dominant logic paradigm [8] have each contributed to discussions regarding the connotations of digital servitization strategies for manufacturing enterprises, offering distinctions among relevant concepts. It has been proposed that digital servitization refers to the process through which enterprises transition towards digital product–service systems, while a digital servitization strategy underscores the deliberate choices made at the macro-level of an enterprise to steer this transformation [9].

However, existing research still has the following limitations:

1. Inadequate Mechanistic Explanations: The construction of digital servitization capabilities often remains at the conceptual framework stage, lacking a breakdown of "how capabilities underpin the implementation of strategies" [6].

2. Weak Dynamic Perspective: Research on strategic choices overlooks the stepwise nature of the evolution of digital servitization capabilities, resulting in an inability to account for the misalignment between strategic choices and capability endowments [10].

3. Absence of a Capability–Strategy Matching Mechanism: The rules governing the alignment between the stage-based development of digital servitization capabilities and strategic types have not yet been clearly defined [11].

These gaps render it challenging for the academic community to address the following question: How should the digital servitization capabilities and strategies of enterprises be matched? This has constrained the practical applicability of theoretical guidance.

To tackle this issue, this study zeroes in on the following core research questions:

RQ1: What types of digital servitization strategies are appropriate for manufacturing enterprises at different capability stages?

RQ2: How does the alignment between the digital servitization capabilities and strategies of manufacturing enterprises influence their performance?

To this end, this study selects three equipment manufacturing enterprises, namely, Sany Heavy Industry (SANY) (Changsha, China), Shaanxi Automobile Group Co., Ltd. (SXQC) (Xi'an, China), and Xi'an Shaangu Power Co., Ltd. (SG) (Xi'an, China). Through a longitudinal case analysis, we trace the interaction between the evolution of enterprise capabilities and strategic adjustments. Subsequently, via a cross-case comparison, we identify the performance disparities among different capability–strategy combinations and present a matching model for the digital servitization capabilities and strategies of manufacturing enterprises.

The contributions of this study are manifested in two aspects: At the theoretical level, ① it proposes a "capability–strategy" co-evolution model, revealing the pattern by which an enterprise's capability leaps from "service data integration → service demand exploration → digital service orchestration", driving their strategic shift from a product-centered to ecosystem-centered approach. ② Based on the dynamic capability theory, this study proposes six matching patterns and verifies the positive effects of three of these patterns, providing an operational theoretical basis for manufacturing enterprises with different capability characteristics to make strategic choices. At the practical level,

we provide enterprises with phased transformation paths (such as avoiding ecosystem strategies in the low-capability stage) to avoid resource misallocation risks.

To systematically address the above questions, this study is organized as follows:

Literature Review: We differentiate the theoretical basis of digital servitization capabilities and strategies and identify existing research gaps.

Research Design: We explain the basis for multi-case selection, variable measurement, and data analysis methods.

Case Analysis: We reveal the mechanism of capability–strategy–performance through intra-case evolution tracking and inter-case matching comparisons.

Discussion and Propositions: We extract and analyze six matching relationships.

Conclusion and Outlook: Finally, we summarize theoretical contributions and practical implications, and then future research directions are provided.

2. Literature Review

2.1. Digital Servitization Capabilities (DSCs)

In recent years, scholars have consistently highlighted the significance of enterprises in cultivating digital servitization capabilities [12]. Evidently, there has been a notable upsurge in academic papers dedicated to digital servitization capabilities.

From the vantage point of dynamic capabilities, Jia [13] put forth three pivotal types of capabilities within the realm of digital servitization: data integration capabilities, data analysis capabilities, and data productization capabilities. Estêvo [14] further elaborated a theoretical framework encompassing four digital servitization capabilities, namely, integration, provisioning, orchestration, and fabrication. Moreover, it was indicated that distinct combinations of these capabilities give rise to varied value-creation outcomes.

The disparities in research findings have drawn scholars' attention to the dynamic and stage-specific attributes of digital servitization capabilities [6]. Through case-based analyses, Marcon [15] synthesized the types of capabilities that manufacturing enterprises, intermediaries, and customers ought to possess at diverse service levels during the digital servitization journey, refining a multi-agent capability inventory. Momeni [5] generalized the development mechanisms of the digital service operation capabilities of manufacturing enterprises across different phases of servitization.

Chirumalla et al. [6] and Chen [7] explicitly advocated that digital servitization capabilities must be deliberated in conjunction with corporate strategies. Nevertheless, to this day, no research has pinpointed the congruence rules between digital servitization capabilities and digital servitization strategies.

2.2. Digital Servitization Strategy (DS Strategy)

In the process of an enterprise's digital servitization transformation, the design and implementation of digital servitization strategies are typically fraught with challenges. This has resulted in a significant capability gap for enterprises [16], thereby attracting the attention of numerous scholars [17].

Currently, most studies on digital servitization strategies employ methods such as case studies or literature analyses. These are used to explore the implementation paths of digital servitization and the strategic directions at different digital servitization stages. For example, Lerch and Gotsch [18] were among the first to generalize the four stages of digital servitization strategies (manufacturer, information technology-based service, pure digital service, and digital product–service system) using the case-study approach. Coreynen et al. [19] proposed three types of digital servitization strategies—namely, industrial servitization, commercial servitization, and value servitization—based on the resource integration scope. Frank [20] further categorized digital servitization strategies

into three types—smoothing, adaptation, and substitution—according to the depth of value creation. Building on numerous stage models, Cimini [9] presented a dichotomy of digital servitization strategies based on the product life cycle and adjacency relationships, including product-centric digital servitization strategies and ecosystem-centric digital servitization strategies.

Although these related classification frameworks are abundant and predominantly focus on stage classification, they have not unveiled the driving mechanisms behind strategic choices (e.g., when does an enterprise transition from one strategy to another?). The successful implementation of a strategy hinges on whether an enterprise possesses the corresponding capabilities [7].

2.3. DS Strategy and DSCs

Existing studies unanimously assert that digital servitization is contingent upon the impetus of capabilities. Kohtamäki et al. [21] and Xie [22] centered their focus on the "technology capability–service integration" process, accentuating how Internet of Things (IoT) and big data capabilities are integrated into service workflows. Estêvo [14] further employed configurational approaches to demonstrate that the strength of digital servitization capabilities dictates the success or failure of an enterprise's transformation trajectory. Nevertheless, these investigations are confined to the micro-level of enterprises.

At the macro-strategic level, Cimini et al. [9] put forward two strategic paradigms —namely, the "product-centric" and "ecosystem-centric" paradigms—and highlighted the substantial disparities in resource requisites for enterprises under different strategic typologies. Chen et al. [10] also stressed that digital servitization is a dynamic evolutionary process, necessitating enterprises to continuously realign their strategic orientations. Kolagar [23] delved deeper into how large-scale manufacturing enterprises coordinate their ecosystems to effectively execute digital servitization strategies. However, the question of at what level of capabilities an enterprise is "eligible" or "obliged" to transition to an ecosystem-based strategy remains systematically unanswered.

Momeni et al. [5] delineated three stages in the development of digital servitization capabilities, yet they failed to correlate them with different types of strategies. Münch et al. [24] identified and classified 46 digital servitization capabilities using the socio-technical system theory and proposed that future research should take into account the evolving nature of digital servitization capability portfolios as enterprises progress in their digital servitization endeavors. The most recent research on AI-enabled services further indicates that the incremental impact boundaries of artificial intelligence capabilities vary across different digital service types [25], thereby underscoring the significance of the "capability–strategy–performance" alignment mechanism.

2.4. Theoretical Dialogue

Based on the existing literature, it is evident that the importance of digital servitization capabilities and digital servitization strategies has been repeatedly emphasized by scholars. The relevant research mainly falls into three major theoretical streams.

(1) The Dynamic Capability Stream

This stream focuses on the micro-mechanisms through which enterprises adapt to the digital environment via capability iteration. It posits that manufacturing enterprises drive their transformation through capability iteration [26]. However, it has not yet refined the capability dimensions within the context of digital servitization. Moreover, there is a lack of deconstruction of how capabilities underpin the implementation of strategies [6].

(2) The Strategic Fit Stream

This stream emphasizes that the effectiveness of a strategy depends on its alignment with organizational capabilities. Although existing studies have explored the relationship between capabilities and strategies (digitization and servitization) [11], they have not clearly elucidated how capabilities at different development stages should be dynamically matched with different types of strategies in the specific scenario of digital servitization. In addition, they have not specified how such a match specifically impacts performance.

(3) The Service-Dominant Logic Stream

This stream emphasizes the ecological paradigm of value co-creation [27]. Nevertheless, it underestimates the restrictive effect of an enterprise's basic capabilities on ecological strategies, thereby resulting in a risk of misalignment between strategic choices and capability endowments [10].

In light of the above, this study is positioned to address this research gap. Its aim is to explore how manufacturing enterprises can dynamically select and align appropriate digital servitization strategies according to the stage-specific characteristics of their digital servitization capabilities, thereby effectively enhancing corporate performance. By delving deeply into the micro-mechanisms and stage-specific patterns of the capability–strategy fit, this study will offer an interpretation of the application of the dynamic capability theory in the context of digital servitization, supplement the stage-specific conditions of capabilities for the strategic fit theory, and address the concerns of the service-dominant logic regarding the constraints of the capability foundation.

3. Methods

3.1. Method Selection

This study employs an exploratory multiple-case research method for the following three principal reasons: First, case studies are conducive to distilling the regularities and causes underlying phenomena and are well suited for exploring questions regarding processes and mechanisms. The present research endeavors to explore how DS strategies and DSCs exert impacts on firm performance. This is a query that focuses on the "how" and the "mechanisms" of enterprises, rather than validating static correlations. Given the nature of this inquiry, a case study, as opposed to empirical research, is a more suitable research approach.

Second, exploratory multiple-case research is appropriate for deciphering new phenomena or research issues that cannot be accounted for by existing theories. Although there has been an abundance of research on the DS strategy of manufacturing firms, relevant theories on digital-service-oriented capabilities are still developing and lack mature measurement scales, which renders it difficult to meet the requirements of statistical research for measurement reliability and validity [28]. Thus, large-sample statistical research methods cannot be adopted.

Third, in a multiple-case study, each case serves as an independent experiment. By comparing the commonalities in the matching mechanisms of the DS strategy and DSCs across different case firms and repeatedly examining the causal relationships, the reliability and validity of the research can be improved, enabling the formulation of more compelling conclusions [29], which single-case studies lack. Although QCA qualitative analysis can analyze multiple concurrent causal relationships, it is difficult to parse the micro-mechanism of matching relationships. A comparison of specific methods is shown in Table 1.

Table 1. Comparison of research methods.

Method	Applicable Scenarios	The Adaptability Defect of This Research
Large-scale sample analysis	Verify the static relationships in mature theories	The construct is not yet mature, and the scale is missing
Single-case analysis	Deeply deconstruct complex phenomena	Lack of comparative verification among cases
QCA	Analyze multiple concurrent causal relationships	The microscopic action mechanism is difficult to analyze and exhibits issues when matching relationships
Multiple-case studies	The questions of "how" and the "mechanism"	

3.2. Case Selection

The aim of this case study is to develop new theories rather than to test existing ones [29]. Thus, this study adheres to the principle of theoretical sampling. In light of the alignment with the research questions, we select three typical manufacturing enterprises with digital servitization practices, namely, Sany Heavy Industry (SANY) (Changsha, China), Shaanxi Automobile Group Co., Ltd. (SXQC) (Xi'an, China), and Xi'an Shaangu Power Co., Ltd. (SG) (Xi'an, China), as the research objects. The specific selection criteria are as follows:

(1) Typicality of Cases: These three enterprises have implemented servitization strategies for several years, and their digital servitization initiatives date back over five years. They have amassed substantial experience in digital servitization, possess unique operational models, and have achieved a certain scale and level of efficiency, rendering them representative.

(2) Diversity of Cases: The three enterprises selected in this study belong to different sub-sectors within the equipment manufacturing industry. This diversity enables comprehensive comparisons among the case enterprises, facilitates multiple verifications, and enhances the accuracy and generalizability of the research findings.

(3) Availability and Integrity of Case Data: The three enterprises selected in this study are renowned in the industry. There is a wealth of publicly available information, including content on their official websites, relevant news reports, and research papers. Moreover, the research team has been continuously monitoring and researching these case enterprises since 2013, accumulating extensive research materials. The general information of the case enterprises is presented in Table 2.

Table 2. Overview of the companies in this case study.

Case Study	SANY	SXQC	SG
Establishment time	1994	1968	1999
Industry affiliation	Construction machinery	Automobile manufacturing	Energy equipment
Main business	Concrete machinery, excavation machinery, lifting machinery, and other mechanical products	Integrated vehicle manufacturing, special-purpose vehicle production, automotive parts and components manufacturing, and after-market services	Energy conversion equipment, industrial services, and energy infrastructure operations
Starting time of DS	2007	2012	2007

3.3. Measurement of Variables

3.3.1. DSCs

DSCs represent a dynamic capability of manufacturing enterprises [6]. Within the framework of the dynamic capability theory, the DSC is defined as the capacity of a firm to leverage digital technologies. These technologies involve the integration, utilization, and configuration of both internal and external data resources, aiming to facilitate the development and delivery of products and services [30]. Drawing on the research of

Chen [7] and Chirumalla [6], this study, in accordance with the three-dimensional categorization of dynamic capabilities, classifies digital servitization capabilities into three aspects: service data integration capability, service demand exploration capability, and digital service orchestration capability (Table 3). The service data integration capability manifests the "perception" dimension by enabling data connectivity through the collection of diverse product or customer data. The service demand exploration capability reflects the "seizing" dimension by deriving valuable business insights from the analysis of service data. The digital service orchestration capability embodies the "transformation" dimension through the capacity to build digital networks for innovative services. Overall, digital servitization capabilities empower companies to perceive, comprehend, and meet the service requirements of customers, thereby attaining the goal of servitization.

Table 3. Classification and feature representation of the variables.

Variables	Measurement	Feature Representation
DS strategy	PCDS strategy	Digital technology embedded in products and value-added services
	ECDS strategy	Cross-enterprise data sharing and platform-based services
DSCs	Service data integration capability	Data collection, interconnection, and interoperability
	Service demand exploration capability	Data analysis and precise insights
	Digital service orchestration capability	Service network reconfiguration and value co-creation
Performance	The financial performance and market performance of enterprises	Operating revenue, profit growth rate, the proportion of labor costs, administrative expenses, selling expenses, awards and honors obtained, industry influence, etc.

3.3.2. DS Strategy

In this study, the classification of the DS strategy follows Cimini's [9] research. Digital servitization (DS) strategies are categorized into two types: product-centric digital servitization (PCDS) strategies and ecosystem-centered digital servitization (ECDS) strategies. This classification approach has gained extensive recognition in the academic realm. Cimini [9] posits that the PCDS strategy encompasses two modalities: "embedded innovators" and "solution providers". "Embedded innovators", which embody the most product-centric stance, entail the incorporation of digital components into products for the purpose of acquiring valuable data and information, in addition to the provision of supplementary services. The "Solution Provider" looks for new connection business opportunities in the activities carried out throughout a product's life cycle.

The ECDS strategy moves beyond the product itself. It involves connecting with network information from diverse sources and providing services based on high-value data volumes. This represents a servitization process oriented towards the ecosystem [16]. Manufacturing enterprises, acting as service providers, make their equipment data available for third-party use (e.g., for overall optimization). Alternatively, they leverage data from different sources to actively offer functions for other equipment.

These two digital servitization strategies exemplify different manifestations of digital servitization (Table 3). Nevertheless, in real-world cases, it is arduous to precisely define the boundaries between these strategies. Hence, in this study, the sample cases are enterprises that, at different transformation stages, are predominantly guided by one particular strategy. The dominant digital servitization strategy type of each case enterprise is determined through qualitative data analysis.

3.3.3. Performance

Only when taking both financial indicators and market indicators into consideration can the performance implications arising from an enterprise's strategic transformation be more comprehensively measured. Consequently, this study primarily utilizes indicators—

such as operating revenue, profit growth rate, the proportion of labor costs, administrative expenses, selling expenses, the honors obtained, and industry influence—to measure enterprise performance (Table 3).

3.4. Data Collection

3.4.1. The Design Logic of the Interview Outline

This study adopts a framework of "theoretical grounding–structural design logic–quality control measures" to ensure the reliability of the data. It follows McCracken's long interview method [31]. Firstly, based on the research questions, three dimensions of "capability evolution", "strategic choice", and "matching performance" are determined as the design dimensions of the interview outline. Dynamic capability theory and the strategic matching model are taken as the theoretical basis to deconstruct the core variables of "digital service capability" and "strategic type" into observable dimensions, ensuring that each interview question targets the core construct and each interview module corresponds to a set of research propositions. Then, the interview question structure is set up through the logic of "situational retrospection–cognitive inquiry–causal linking", with follow-up prompts set for each section. After completing the initial interview outline, two rounds of expert pre-assessments are conducted, involving professors and experts in the field. The interview outline is revised and improved based on the feedback from the experts to form the final version of the interview outline. Finally, "triangulation verification" is used to ensure content validity.

3.4.2. Principles and Screening Criteria for Data Collection

In order to ensure the validity of the case study, this research adheres to the principle of "triangulation" during both the data collection and analysis phases [32]. Multiple data collection and cross-verification methods are employed, including archival records, literature research, and interview data, which helps avoid common methodological biases to a certain degree and improves the reliability and validity of this study. The main data sources are as follows (Table 4).

Firstly, the interview data were collected. First-hand data were obtained by integrating semi-structured in-depth interviews and open-ended interviews. The interviewees consisted of middle-level and senior managers from key departments (such as the Strategic Management Department, the System Solutions Department, the Digitalization Department, etc.) during the digital servitization transformation of the case enterprises, front-line business staff, and customers. Specifically, 8 face-to-face interviews were conducted, with the duration of each interview ranging from 60 to 120 min. Moreover, 10 interviews were carried out via Tencent Meeting using a telephone, with the duration of each interview controlled between 60 and 90 min. All interviews were recorded using voice recorders or the recording functions of mobile phones after obtaining the consent of the interviewees. All written drafts were returned to the respondents for confirmation. After revisions, they signed a consent form, and the documents were archived.

Secondly, regarding the archival materials, the research group accessed relevant information about the enterprises' digital servitization, performance, etc., through multiple channels. These included official media platforms, such as the enterprises' official websites, WeChat public accounts, and Weibo accounts; traditional media such as news reports, newspapers, and magazines; and certain internal documents.

Thirdly, in terms of the literature resources, research studies on the digital servitization of case enterprises indexed by SSCI, SCI, and CSSCI within the past five years were retrieved mainly through databases such as CNKI. Isolated information that could not be cross-verified either in the interviews or in the literature was excluded.

Ultimately, the total word count of the collated text reached 377,000 words.

Table 4. Data collection path.

Source	Enterprise	Interviewee	Time	Duration	Approach	Screening Criteria	Triangular Verification Method
Interview	SANY	General Manager of the Digitalization Department, Secretary to the General Manager	April 2020	70 min	Face to face	Managers or key personnel in critical departments with at least 5 years of working experience	Interview recording → transcription of text → confirmation by interviewee → cross-checking with annual report
		Deputy Minister of Strategic Management and R&D Director	August 2024	80 min	Face to face		
		Deputy General Manager of the Digitalization Department and Chief Engineer of the System Solutions Department	April 2020–October 2020	Three sessions totaling 3 h	Tencent meeting		
	SXQC	The head of the Enterprise Management Department and the technical backbone of the Digitalization Department	August 2021	90 min	Face to face		
		The head of the Strategic Management Department and key employees	June 2024	70 min	Face to face		
		Key business personnel of the Marketing Department	September 2024	70 min	Face to face		
		Technical backbone of the Digitalization Department and employees of the Strategic Management Department	November 2022–April 2023	Three sessions of 2.5 h each	Tencent meeting		
	SG	Chairman of the enterprise	November 2020	90 min	Face to face		
		Minister of the System Solutions Department	October 2023	90 min	Face to face		
		The head of the Strategic Management Department, the head of the Enterprise Management Department, and two department employees	December 2023	150 min	Face to face		
		Office Director and Key Member of the System Solutions Department	March 2024–June 2024	210 min	Tencent meeting, telephone		
Archival materials	SANY, SXQC, and SG	Official media channels such as the enterprise's official website and official WeChat and Weibo accounts; news reports, newspapers, and magazines; conference PPTs; etc.	The growth rate of the case enterprise's operating income/profit, digital service-oriented investment, and related reports on the case enterprise's digital service-oriented transformation			Official channel release	Annual report data ←→ interviews ←→ third-party reports
Literature and materials	SANY, SXQC, and SG	27 journal papers have been published in the past five years	Literature on the implementation of digital service-oriented strategies and the construction of digital service capabilities in case enterprises			CSSCI, SCI, and SSCI journals; published within five years	Literature ←→ interviews ←→ annual report data

3.5. Data Analysis

To more comprehensively analyze the alignment between the DSCs of case enterprises and the adopted DS strategies and to contrast the differential mechanisms through which various alignment scenarios influence enterprise performance, this study follows the approach proposed by Miles (1984) [33]. The analysis is carried out through both intra-case and inter-case analyses.

Intra-case analysis involves a meticulous descriptive analysis of the DSC, DS strategy, and enterprise performance of manufacturing enterprises. Specifically, it aims to dissect the intricate details and characteristics within each individual case. Inter-case analysis, on

the other hand, is a comparative assessment of how different alignments between digital servitization strategies and capabilities impact performance. The goal is to ultimately identify the nature of the alignment relationship between the two. The detailed procedures are as follows.

Firstly, in the intra-case analysis stage, for each case, data reduction and data presentation techniques are employed. Case data are archived and coded in accordance with the conceptual definitions and measurement methodologies of each variable. This systematic approach allows for a structured and organized examination of the data within each case. Secondly, during the inter-case analysis phase, this study compares the variances in the performance impacts resulting from different alignment patterns of the DS strategy and DSCs. By examining the three enterprises, similarities and differences in their DSCs and DS strategies are identified. Through iterative comparisons, commonalities and differences across cases are established. Drawing on the principle of sensitivity in chaotic systems, we stimulate the source of key events, capture the response of system disturbances, determine the enterprise's strategic decision-making chain, and ultimately distill specific propositions [34].

4. Case Analysis and Major Findings

4.1. Intra-Case Analysis and Findings

We conducted a preliminary collation of the data collected from the three cases. The acquired textual information was archived under each predefined concept, thus laying a foundation for clarifying the relationships between concepts in the subsequent stage.

4.1.1. DSCs of Case Enterprises

DSCs consist of three types: service data integration capabilities, service demand exploration capabilities, and digital service orchestration capabilities. Among the enterprises in this case study, all three have developed these three capabilities in light of their respective development situations (Table 5).

Table 5. Digital servitization capabilities of the enterprises in this case study.

Enterprise	Digital Servitization Capabilities	Specific Approaches	Representative Evidence
SANY	Service data integration capabilities (2007–2011)	It is imperative to strive to break through the internal data silos of enterprises by means of technological approaches.	Deploy production equipment, logistics equipment, etc., for integration with the Internet of Things platform, enabling real-time data acquisition and transmission. Establish a preliminary data hub. Facilitate the substitution of labor with machines and simultaneously monitor the status of equipment via sensors.
	Service demand exploration capability (2012–2017)	Optimize business processes by conducting in-depth data analysis and obtaining profound customer insights. Transition from a passive stance of merely responding to customer demands to an active approach of proactively uncovering customers' latent needs.	Utilize tools, including the "Customer Cloud" APP v8.1.3 and CRM v1.0 system, to gather customer usage data. Integrate machine learning techniques to construct a "digital profile" of customers, thereby accurately discerning personalized requirements. Introduce scenario-specific solutions, such as "Ecological Smart Wind Power" and "Smart Mines". This extends customer demands from the procurement of single equipment to comprehensive life-cycle management.

Table 5. *Cont.*

Enterprise	Digital Servitization Capabilities	Specific Approaches	Representative Evidence
	Digital service orchestration capability (2018–2024)	The digital platform collaborates in harmony with the ecosystem to enable the online and intelligent delivery of services across the entire value chain, thereby endowing the external industrial chain with enhanced capabilities.	Through the RootCloud v1.0 platform, the real-time operating status of equipment across the globe is monitored. As a result, the fault repair rate has witnessed a 50% increase. By leveraging the open capabilities of the platform, upstream and downstream enterprises are empowered. For example, in collaboration with Shugen Internet, digital service capabilities are disseminated to industries, including environmental protection and logistics, thus giving rise to a cross-domain service ecosystem.
SXQC	Service data integration capabilities (2015–2020)	Centering on data integration and the enhancement of internal efficiency, the realization of data interconnection is achieved via technical tools.	By virtue of Internet of Things (IoT) technologies, the interconnection of production equipment is accomplished. Subsequently, a data hub platform is established to integrate data from various aspects such as production, quality, and logistics. Through the vehicle networking system, data regarding vehicle operations is gathered, which provides the necessary data foundation for remote fault diagnosis and the supply of spare parts.
	Service demand exploration capability (2021–2024)	Centering on precise customer-demand-driven services, service content is optimized through data analysis.	It is feasible to analyze customers' operational data via the "Tianxingjian v3.2.8" Vehicle Networking Platform, offering suggestions for optimizing fuel consumption and vehicle health management services. This platform supports the early warning of malfunctions and the optimization of customers' operations. By means of the management cockpit, the full cycle of orders can be monitored in real time to unearth the collaborative value of the supply chain.
SG	Service data integration capabilities (2007–2015)	The interconnection of equipment and the interoperability of data are realized. Through technical measures, the data silos within enterprises are eliminated.	By integrating resources via the industrial Internet, a Turbine Equipment MRO v1.0(SG, Xi'an, China) management system oriented towards the full life cycle of equipment was constructed. This system enables the monitoring of equipment status and the diagnosis of faults. Through the integration of data via research and development, production, and the supply chain by means of systems such as ERP and CRM, a data hub platform was preliminarily established to support cross-departmental collaboration.
	Service demand exploration capability (2016–2018)	Shift from a "product-centric" approach to a "customer-centric" approach.	The remote monitoring and diagnostic platform encompasses 1200 pieces of equipment globally. By collecting customers' usage data and integrating machine learning techniques, a "digital profile" of customers is constructed to accurately identify personalized requirements. The "Distributed Energy System Solution" and the "Energy Interconnected Island" technology were introduced to integrate energy systems, such as cooling, heating, electricity, and water.

Table 5. *Cont.*

Enterprise	Digital Servitization Capabilities	Specific Approaches	Representative Evidence
	Digital service orchestration capability (2019–2024)	The industrial chain is empowered through models such as supply-chain finance and intelligent logistics. For example, the Lianyide Supply Chain Company was established to integrate the trading of bulk commodities and financial services.	The industrial Internet platform for intelligent operation and maintenance of equipment in the process industry was completed. It encompasses 300 users and more than 1200 core pieces of equipment. Leveraging the online services of this platform, the company has acquired the capacity to offer users systematic services, including monitoring and diagnosis, condition assessment, and inspection and maintenance guidance.

4.1.2. DS Strategy of Case Enterprises

In the case-study enterprises, manufacturing firms make distinct strategic selections according to the capability characteristics at different corporate development stages. The three enterprises have successively adopted PCDS and ECDS strategies (Table 6).

Table 6. DS strategy of case enterprises.

Enterprise	DS Strategy	Concrete Approaches	Exemplary Evidence
SANY	PCDS strategy (2008–2011)	Leverage digital technologies to elevate the intelligence quotient of products.	Opt to provide remote operation and maintenance services, including remote fault diagnosis and predictive maintenance, centered around the product. For example, the "Customer Cloud" APP v8.1.3 is offered to enable one-click service solicitation. The enterprise's back-end system can rapidly pinpoint issues through data analysis.
	ECDS strategy (2012–2024)	Transcend the boundaries of single-product offerings and integrate industrial chain resources to formulate comprehensive solutions.	The Board of Directors set the establishment of an intelligent industrial chain cluster ecosystem as its goal, and they developed digital products, including the "Genyun Platform" and the "Yiweixun v17.2.3.1" APP, to enable the construction and operation of the industrial chain service platform.
SXQC	ECDS strategy (2015–2022)	Through the integration of resources in a platform-based and scenario-specific manner, an ecologically closed "technology + service + data" loop is established.	Formulate an integrated solution model encompassing "Internet of Vehicles + Finance + Aftermarket". Conduct an in-depth analysis of vehicle usage data to optimize product performance. Place emphasis on the management of ecological partners. Collaborate with upstream and downstream enterprises such as FAST and HANDE Axle to jointly explore international markets, thereby establishing an industrial ecosystem featuring "R&D + manufacturing + service". This approach is designed to stimulate collaborative innovation within the supply chain.
	PCDS strategy (2023–2024)	Devote attention to elevating production output, decreasing costs, and augmenting the level of product intelligence through digital technologies during both the production and application phases of products.	SXQC has strategically planned and established intelligent production factories to boost production volume. In collaboration with enterprises such as Huawei, it has launched a panoramic ecological model integrating "green products + super-fast charging + intelligent networking + segmented scenarios". This initiative is designed to optimize the power utilization efficiency within the logistic scenarios of electric heavy-duty trucks, thereby constructing a high-quality and highly efficient ecological closed-loop system.

Table 6. *Cont.*

Enterprise	DS Strategy	Concrete Approaches	Exemplary Evidence
SG	PCDS strategy (2007–2015)	Centered around equipment manufacturing, efforts are made to extend services associated with product functions.	Shift from solely selling equipment to extending services to include fundamental offerings such as installation, commissioning, inspection, and maintenance. Establish a data center platform to preliminarily accomplish the monitoring of equipment operating conditions and fault diagnosis.
	ECDS strategy (2016–2024)	An ecological service network that takes customer needs as its core integrates resources across the industrial chain to offer comprehensive solutions.	With distributed energy system solutions at its core, a strategic layout was implemented to integrate seven value-added services, namely, equipment, EPC (engineering, procurement, and construction), services, operation, and finance. In 2019, SG launched the "Chain-Easy-Access" supply-chain service platform, aiming to realize the interconnection and interoperability of resources upstream and downstream of the industrial chain.

4.1.3. Performance of Case Enterprises

In the DS transformation process of manufacturing enterprises, the outcomes of implementing DS can be directly mirrored by performance. Moreover, at different stages of the DS strategy, the performance results are likely to differ (Table 7).

Table 7. Performance of the case enterprises.

Enterprise	Phase	Typical Data of Corporate Performance
SANY	2008–2011	During the period from 2009 to 2011, SANY exhibited a notable upward trend in both sales revenue and profits. The sales revenue increased from CNY 18.976 billion to CNY 50.776 billion. Over the course of these three years, profits also increased from CNY 1.906 billion to CNY 8.649 billion. Moreover, the proportion of labor costs to revenue decreased to 4.74%. In July 2011, SANY was recognized as one of the top 500 companies in the world in terms of market value, thereby becoming the first domestic enterprise to be included in this prestigious list.
	2012–2015	Between 2012 and 2015, SANY experienced a substantial decline in sales volume. The operating revenue decreased from CNY 46.832 billion to CNY 23.367 billion, representing a contraction of 52% compared to the peak in 2011. This situation resulted in losses and deficits that had not been witnessed for several years. In 2012 and 2013, respectively, the total profit of the enterprise declined by 34.26% and 39.32%.
	2016–2024	In the "Service 10,000 Miles" initiative carried out in 2020, the inspection and parameter calibration of more than 20,000 excavators were automatically accomplished via terminals. This achievement resulted in a 50% reduction in manpower requirements and a twofold increase in efficiency. Currently, 98% of SANY's service operations can be conducted online. This has significantly enhanced both service efficiency and service coverage. In 2017, Root Internet, which was developed by the Internet of Things Division, emerged as one of the three major industrial Internet platforms in China. According to the list of the world's top 50 construction machinery manufacturers in 2020 released by the British magazine *International Construction*, the ranking of SANY ascended from the ninth place in 2015 to the fifth place globally. In the first three quarters of 2024, the operating revenue increased by 3.9%, and the gross profit increased by 28.3%.
SXQC	2015–2020	The micro-vehicle business incurred successive losses. The operating revenue dropped precipitously from CNY 247 million to CNY 33 million, and the company reported negative gross profit for three consecutive years. In the heavy-truck market, the growth rate decelerated. In 2015, the company initiated a transition towards new energy, yet the strategic layout progressed at a sluggish pace. As a result, the market share remained below 5%.
	2021–2022	The new-energy business of SXQC demonstrated relatively limited competitiveness. In 2022, although its hydrogen-fueled heavy-duty trucks ranked second in terms of sales volume within the industry, the proportion of its core patents accounted for only 45%. As the technological moat remains underdeveloped, the company faced challenges in competing with companies such as BYD.
	2023–2024	During 2023 and 2024, the vehicle sales volume of SXQC exhibited a continuous upward trend. At present, its market share reaches 16.6%, ranking third within the industry. The sales volume of new-energy vehicle models exceeded 10,000 units, registering a year-on-year growth rate of 200%. The new-energy light-truck segment witnessed remarkable performance. Specifically, the Zhiyun S300 model firmly maintained the second-highest sales volume in the industry. The "5G New Energy Heavy-Truck Intelligent Manufacturing Application and Practice Industrial Park", which was established in 2022, carried out unmanned operation throughout the entire production process of vehicle frames. As a result, production efficiency was enhanced by 40%. The painting workshop optimized energy consumption by leveraging big data technology, resulting in annual cost savings of CNY 8.19 million.

Table 7. *Cont.*

Enterprise	Phase	Typical Data of Corporate Performance
SG	2007–2015	For enterprises applying power equipment, the downtime was curtailed by over 20%. Simultaneously, equipment maintenance costs were trimmed by 10%, and the amount of funds tied up in spare parts was slashed by 20%. In the context of the main business, the operating revenue from energy conversion equipment gradually declined. Conversely, the operating revenue from services and the operation of energy infrastructure increased annually.
	2016–2018	The company ventured into new domains, including distributed energy cogeneration and clean energy in the coal chemical industry, and it carried out numerous first-of-its-kind projects. Through process reengineering and supply-chain integration, both the management expense ratio and the sales expense ratio experienced a decline. From 2015 to 2017, the company's operating revenue demonstrated a sustained upward trend.
	2019–2024	The energy consumption per CNY 10,000 of the output value of SG's Energy Internet Island stands at merely 4.52 kg of standard coal. At present, it is the smart manufacturing base within the global industry that features the lowest energy consumption and the least emissions per CNY 10,000 of the output value. The total operating revenue has increased from CNY 3.96 billion to CNY 10.36 billion. Both the revenue and profit of the digital industry have hit historical peaks, with the digital economy accounting for 96.9% of the total. The proportion of industrial services and operations in the total sales orders reached 80.61%. In 2021, SG was recognized by the Ministry of Industry and Information Technology of the People's Republic of China as a "Demonstration Factory for Intelligent Manufacturing of Large-scale Power Equipment" and a "Demonstration Unit for Green Design of Industrial Products".

4.2. Inter-Case Analysis and Findings

Through a horizontal comparison of the data of the three case enterprises, it can be observed that, in recent years, manufacturing enterprises are endeavoring to expand their profit streams and attain differentiated competitive edges by means of digital servitization transformation [35]. Upon conducting both horizontal and vertical analyses of the three cases, it was evident that there exists a certain degree of congruence between an enterprise's DSCs and its DS strategy, and this relationship exerts a notable influence on enterprise performance.

Case studies have revealed that when an enterprise's capabilities reach a certain threshold, by adopting a corresponding DS strategy, the enterprise can enhance its performance, cut down service costs [36], shorten the delivery cycle, create new revenue channels, strengthen its competitiveness, and explore new business prospects [21]. Divergent matching approaches have distinct impacts on enterprise performance. Specifically, both the service data integration capability and the service demand exploration capability exhibit a favorable alignment with the PCDS strategy. In contrast, the digital service integration capability demonstrates a good fit solely with the ECDS strategy. Figure 1 shows the stage divisions of the development of the three case enterprises.

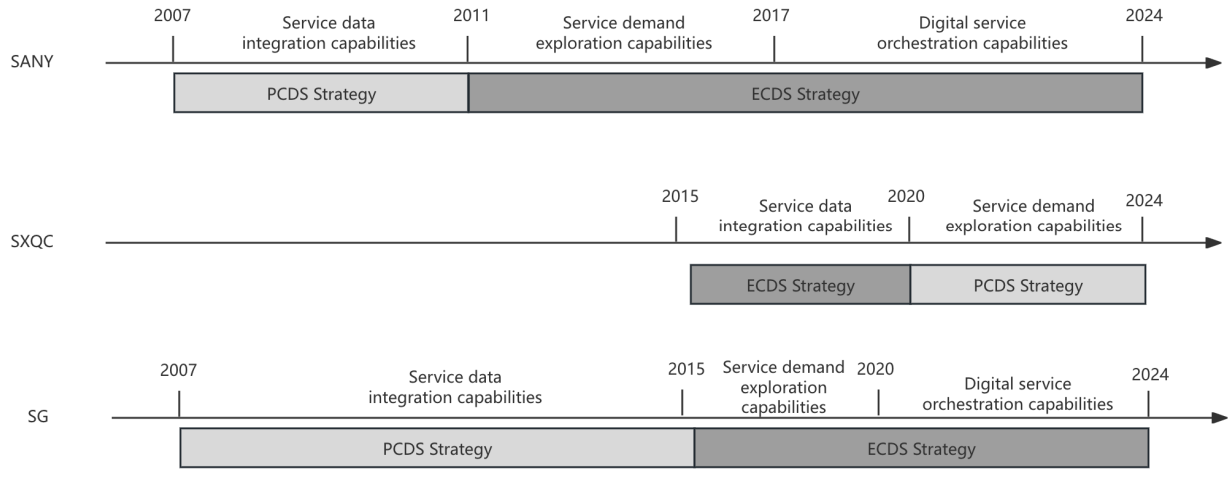

Figure 1. Division of the development stages of the case enterprises.

4.2.1. The Alignment Between DSCs and the PCDS Strategy

Within the theoretical framework of dynamic capability theory, this study posits that the compatibility between low-order DSCs (service data integration capabilities/service demand exploration capabilities) and the PCDS strategy is attributable to the resource focusing effect.

When enterprises integrate full-life-cycle product data by leveraging Internet of Things technologies, the PCDS strategy can channel the value of data towards optimizing product functions, thereby shortening the service cost recovery cycle [37]. The service data integration ability is employed in various service operation activities, including research and development, product architecture design, production processes, sales services, and operational management. The cross-regional, cross-industry, and cross-enterprise flow and sharing of data elements enhance the production efficiency and resource utilization of enterprises. This is conducive to preventing and resolving research and development risks, improving the quality of product research and development, and facilitating the transformation of knowledge achievements [38].

The service demand exploration ability serves to identify the market dynamics associated with products, recognize customers' demands for new services, and evaluate the opportunities presented by these changes [39].

(1) SANY's "Service data integration capability + PCDS Strategy" (2007–2011)

Between 2007 and 2011, SANY was in the initial stage of its DS, with relatively limited DSCs. In 2008, SANY first carried out a digital factory pilot project within its Crane Business Division. It was outfitted with intelligent processing, warehousing, transportation, and process control systems, eventually attaining intelligent control throughout the entire product process. In 2009, SANY introduced the Manufacturing Execution System (MES) in its small excavator workshop. This system comprehensively integrated multiple aspects, including material blanking, distribution, rework, and warehousing. As a result, it successfully achieved the visualization and intelligent transformation of production, management, quality inspection, and service. Moreover, it established the industry's first fully automated production line and implemented end-to-end digital production management, thereby reflecting the firm's formidable service data integration capabilities.

During this period, the enterprise's digital technology application capabilities were constrained. It adopted a PCDS strategy, with the primary strategic objectives of enhancing product production quality, shortening delivery times, and reducing costs. Specifically, the following were achieved:

① SANY further extended its remote product monitoring service. In 2007, SANY initiated the construction of the ECC system. Leveraging Internet of Things technology, it was able to carry out real-time monitoring and data analysis on its global equipment. By 2011, the ECC had integrated over 200,000 devices, spanning the global market, and provided services such as equipment fault diagnosis and remote machine locking.

② SANY continuously enhanced the efficiency of product services. In April 2010, SANY's service department took the lead in the industry by introducing the "123" service value commitment, the "110" service speed commitment, and the "111" service resource commitment.

In terms of the implementation outcomes, notable performance improvements were achieved.

During this period, the global industrial machinery sales volume of SANY witnessed a substantial increase. By 2011, the figure soared to USD 182.814 billion, and it emerged as the first Chinese construction machinery enterprise to be included in the Fortune Global 500. These data demonstrate that, during this phase, there was a favorable alignment effect between the enterprise's service data collection capabilities and the PCDS strategy.

(2) SG's "Service data integration capability + PCDS Strategy" (2007–2015)

SG (from 2007 to 2015) achieved commendable performance improvements by enhancing its service data integration capabilities and opting to implement a PCDS strategy. The enterprise established the "Intelligent Cloud Service Platform for the Operation, Maintenance, and Health Management of Power Equipment", with SG as the core entity. By integrating equipment data, it successfully reduced the downtime of enterprises using power equipment by over 20%. The enterprise independently developed a new-generation "Top-pressure Energy Recovery System for Improving the Blast Furnace Smelting Intensity". Additionally, through its research on EAOC (Comprehensive Energy Efficiency Analysis and Operational Optimization Control) technology, it integrated equipment data to ensure safe equipment operation. This reflects the enterprise's robust service data integration capabilities.

Based on this, SG also selected a PCDS strategy, providing customers with 24 h monitoring, early warning of equipment failures, and fault diagnosis consultation with respect to the equipment. From 2012 to 2015, the company saved 10% on equipment maintenance costs and reduced the amount of funds required for spare parts by 20%. With respect to its main business, the revenue from energy conversion equipment gradually decreased, while the revenue from services and energy infrastructure operations increased year by year.

(3) SG's "Service demand exploration capabilities + PCDS Strategy" (2016–2018)

From 2016 to 2018, the DSCs of SG underwent notable transformations, gradually evolving their capability to identify and address service requirements. In 2017, SG established the Global Operations Center of the "Energy Interconnected Island". Leveraging big data analytics, it delved into customers' energy needs and, through the application of Internet technologies, offered customers solutions for highly efficient energy utilization and intelligent management and control. SG manifested a robust ability to identify service requirements. It initiated data mining based on equipment monitoring data to meet customers' needs for system services, such as equipment diagnosis, condition assessment, and maintenance guidance. As a result, it has cumulatively helped users reduce losses by more than CNY 100 million.

During this stage, SG continued to implement a PCDS strategy, leveraging intelligent products to propel its servitization transformation. Customers in traditional manufacturing industries have transitioned from simply purchasing equipment to actively seeking solutions for the entire product life cycle. For example, customers in industries such as metallurgy and petrochemicals not only demand core equipment such as compressors but also supplementary services, including remote monitoring, energy-efficiency optimization, and spare-part leasing. These services aim to mitigate the operational costs and risks associated with the products.

From 2016 to 2018, the firm's operating revenue witnessed a continuous upward trend. In 2018, the sales orders of SG's "Industrial Services + Energy Infrastructure Operations Segment" accounted for 77.99% of the total sales orders. These data suggest that the firm's DSCs have reached the service requirement identification stage. Moreover, the adoption of a PCDS strategy has a positive and reinforcing impact on the firm's performance.

(4) SXQC's " Service demand exploration capabilities + PCDS Strategy" (2021–2024)

From 2021 to 2024, SXQC was able to analyze customers' operational data via the "Tianxingjian" vehicle networking platform. Based on the analysis results, it provided suggestions for optimizing fuel consumption and vehicle health management services, and it supported fault early warning and the optimization of customers' operations. This is an indication of the firm's ability to identify service requirements.

During this period, SXQC initially decided to continue its ecosystem-centered digital servitization transformation. However, this did not yield favorable performance outcomes (a detailed discussion is presented in the next section).

In 2023, the company shifted its focus to a PCDS strategy. The primary reason for this shift was that the company recognized the following phenomena: "since heavy trucks are production means, customers are more concerned about product performance indicators such as fuel consumption, reliability, and maintenance costs. At present, the company lacks the capabilities to support ecosystem-centered services."

Consequently, SXQC chose to optimize the full-life-cycle management of its products through digital approaches. For example, it used the "Tianxingjian" vehicle networking platform to monitor vehicle operation data in real time, aiming to reduce the failure rate and improve after-sales efficiency. Additionally, SXQC collaborated with companies such as Huawei to introduce a panoramic model featuring "green products + super-fast charging + intelligent networking + segmented scenarios." This model was designed to enhance the power utilization efficiency in the logistics scenarios of electric heavy trucks, thereby directly addressing customers' comprehensive product requirements.

Regarding implementation effectiveness, in 2023 and 2024, the vehicle sales volume of SXQC experienced a continuous upward trend. Currently, its market share stands at 16.6%, ranking third in the industry. The sales volume of new-energy vehicle models exceeded 10,000 units, registering a year-on-year growth rate of 200%.

(5) Digital service orchestration capabilities + PCDS strategy

In the case of the enterprises under study, no combination of digital service orchestration capabilities and PCDS strategies exists. This research posits that digital service orchestration capabilities denote an enterprise's capacity to innovate services by constructing service networks. At this juncture, selecting a PCDS strategy is inappropriate. In other words, there is no congruence between digital service orchestration capabilities and PCDS strategy.

On the one hand, digital service orchestration capabilities accentuate an enterprise's utilization of externally sourced knowledge with low relevance to establish service networks and drive service innovation. This represents an advanced phase of digital servitization capabilities. Conversely, the PCDS strategy involves manufacturing enterprises leveraging digital technologies to optimize existing services or develop novel services in relation to products, emphasizing knowledge relevance. The two diverge significantly in terms of enterprise resource allocation, likely giving rise to management disarray.

On the other hand, digital service orchestration capabilities advocate for the provision of context-specific solutions via service networks, aligning with the core tenets of service-dominant logic. In contrast, the PCDS strategy remains entrenched in the product-dominant logic paradigm.

Based on the foregoing analysis, the following propositions are put forward:

Proposition 1: For manufacturing enterprises whose DSCs are exhibited by their service data integration capabilities, adopting a PCDS strategy can contribute to the enhancement of corporate performance.

Proposition 2: For manufacturing enterprises whose DSCs are manifested in service demand exploration capabilities, adopting a PCDS strategy can contribute to the improvement of enterprise performance.

Proposition 3: For manufacturing enterprises with DSCs that are manifested in digital service orchestration capabilities, adopting a PCDS strategy has an inhibitory effect on corporate performance.

4.2.2. DSCs and the ECDS Strategy

Through continuous investments in digital technologies, the DSCs of the three case enterprises have successively traversed the stages of service data integration, service demand exploration, and digital service orchestration capabilities.

When the DSCs of manufacturing enterprises reach the digital service orchestration capability stage, the core objective lies in constructing an open-ended service network by dynamically integrating internal and external service components and coordinating the resources of multiple stakeholders. Therefore, for enterprises, implementing an ECDS strategy facilitates the breaking of organizational boundaries and enables service innovation through value co-creation and ecological synergy.

(1) SXQC's "Service data integration capability + ECDS Strategy" (2012–2020)

From 2012 to 2020, SXQC demonstrated a relatively low level of DSCs. Primarily, it achieved the interconnection of production equipment via Internet of Things (IoT) technologies, established a data hub platform, and integrated data from various subsectors, such as production, quality control, and logistics. Moreover, through the vehicle networking system, it collected data on vehicle operations, providing support for remote fault diagnosis and spare-part supply. This was manifested as a relatively strong service data integration capability.

During this phase, the enterprise adopted an ECDS strategy. It formulated an integrated solution model encompassing "vehicle networking + finance + aftermarket services". By analyzing vehicle usage data, the company optimized product performance. With an emphasis on the management of ecological partners, SXQC collaborated with upstream and downstream enterprises, such as Shaanxi Fast Auto Drive Group Co., Ltd. (FASTGEAR) (Xi'an, China) and Shaanxi Hande Axle Co., Ltd. (Hande Axle) (Xi'an, China), forming an industrial "R & D + manufacturing + services" ecosystem by "joining hands to explore overseas markets".

Nevertheless, the data collaboration between the enterprise's production side and external cooperation manufacturers still depends on traditional information platforms. The real-time sharing of data across the entire value chain has not been achieved. The data sharing capacity is insufficient to support the strategic objectives of the industrial ecosystem, thereby causing the strategic implementation results to fall short of expectations.

During this stage, SXQC's operating revenue dropped significantly from CNY 247 million to CNY 33 million, and it incurred gross profit losses for three consecutive years. The growth rate of the heavy-duty truck market decelerated. In 2015, the company initiated its transformation towards new energy, yet the progress of its strategic layout was slow, and its market share remained below 5%.

(2) SANY's "Service demand exploration capabilities+ ECDS Strategy" (2012–2017)

From 2012 to 2017, SANY's DSCs shifted from service data integration capabilities to service demand exploration capabilities. In 2014, for customers of mining machinery, the company optimized the maintenance cycle of the hydraulic system through data analysis, reducing customers' downtime losses by more than 30%.

In 2016, the company established an Internet marketing platform and facilitated the implementation of a Customer Relationship Management (CRM) system. By collecting the real-time operational data of equipment, including fuel consumption, fault codes, and operating hours, it constructed a database of customer equipment usage behaviors. These efforts comprehensively reflect the company's robust service demand exploration capabilities.

During this period, SANY adopted an ECDS strategy, which is manifested in the following aspects: Firstly, by leveraging equipment data, the company developed the "Excavator Index", thereby establishing a cross-industry data-sharing ecosystem. This index

has emerged as a crucial indicator for gauging infrastructure investment and economic trends. Secondly, aiming to integrate global sales channels and technological resources, SANY acquired Putzmeister, Germany. It then established a localized service system spanning regions such as Europe and the Middle East. Additionally, through the GPS, the company manages over 3000 suppliers, optimizing the response speed of the global supply chain.

Nevertheless, over these three years, although the market share of excavators has increased and, as per the report issued by the China Quality Association, the service satisfaction of SANY's products held a clear leading position in the industry, the overall sales volume of the enterprise still exhibited a downward trajectory. The operating revenue decreased from CNY 46.832 billion to CNY 23.367 billion, and the total annual profit declined by more than 30%. Regarding the contributing factors, apart from the domestic construction machinery industry entering a phase of prolonged decline, it was also associated with the company's inaccurate assessment of the situation and the premature implementation of the ECDS strategy. At this juncture, the closed-loop linkage among customer service data, research and development, and production had not yet been achieved. Additionally, the excessive business expansion resulted in a significant increase in expenditures.

(3) SXQC "Service demand exploration capabilities + ECDS Strategy" (2021–2022)

From 2021 to 2022, SXQC was capable of analyzing customer operation data via its "Tianxingjian" Internet of Vehicles (IoV) platform, offering fuel consumption optimization suggestions and vehicle health management services. The IoV platform has cumulatively managed data from nearly one million vehicles, processing an average of 3 TB of data per day. It supports early fault warnings and customer operation optimization. By leveraging a unified big data analysis platform to integrate internal production data and external public sentiment information and by monitoring the entire order cycle in real time through a management cockpit, SXQC has explored the collaborative value of the supply chain. These endeavors all mirror the company's ability to identify service demands.

However, during this period, the primary functions of SXQC's IoV mainly centered on internal vehicle monitoring and the identification of after-sales maintenance requirements. There was insufficient exploration of deeper customer operational needs, such as transportation efficiency optimization and energy consumption management. This has resulted in a delay in responding to customer-customized requirements. Nonetheless, the company still opted for an ECDS strategy. This ecosystem strategy places emphasis on "intelligent industrial chain clusters". Nevertheless, the data-sharing mechanism remains imperfect, and full-process collaboration across design, verification, and production has not been carried out. This has constrained the service innovation response speed.

Consequently, in terms of implementation outcomes, SXQC's new-energy business has shown relatively weak performance. Although its hydrogen-fueled heavy trucks ranked second in sales in the industry in 2022, the proportion of core patents accounted for only 45%. As the technical barrier has not been fully established, it is challenging for the company to compete with enterprises such as BYD.

(4) SANY's "Digital service orchestration capability + ECDS Strategy" (2018–2024)

In 2018, the DCSs of enterprises were further enhanced, and this was observed in the digital service orchestration capabilities achieved through digital network-based service innovation. In that year, SANY launched the "Yiweixun" APP for the intelligent management of excavator equipment. During the "Service 10,000 Miles" project in 2020, the inspection and parameter calibration of over 20,000 excavators were automatically completed via intelligent terminals. This achievement not only reduced the manpower requirement by

50% but also doubled the efficiency, thereby highlighting the company's strong digital service orchestration capabilities.

During this period, SANY steadfastly implemented a DS centered around the ecosystem, making strategic plans and arrangements for the platform's ecosystem network. SANY invested substantial resources in developing the "Rootink" project. By integrating various types of industrial production equipment, it established an industrial Internet platform encompassing more than 20 industrial chains. This platform has provided enabling services to 81 sub-industries and is connected to assets worth over CNY 500 billion.

In light of the implementation outcomes, currently, 98% of the service operations of SANY can be carried out online. The time consumed for fault diagnosis has diminished by 70%, the fault repair rate has witnessed an increase of 8 percentage points, and customer complaints have declined by around 40%. The company's operating revenue reached CNY 10.956 billion, and its global market share has grown from 3.4% to 5.4%.

(5) SG's "Digital service orchestration capability + ECDS Strategy" (2019–2024)

SG (2019–2024) introduced the Energy Internet Island technology. Leveraging Internet and big data technologies, it achieved systematic interconnection between cooling, heating, power, ventilation, water, waste treatment, fire protection, security, and monitoring systems within industrial parks. The company offers users a range of systematic services, including equipment monitoring and diagnosis; condition assessment; and inspection, maintenance, and repair guidance. During this period, its DSCs gradually evolved from service demand exploration capabilities to digital service orchestration capabilities. Consequently, SG implemented an ECDS strategy, providing customers with comprehensive digital product service system solutions.

Specifically, the company has developed an industrial Internet platform for the intelligent operation and maintenance of equipment in the process industry. This platform encompasses 300 users and more than 1200 core pieces of equipment. By means of online services provided through this platform, the company offers users systematic services, including monitoring and diagnosis; condition assessment; and guidance on inspection, repair, and maintenance. These services have enabled users to recoup production losses amounting to hundreds of millions of CNY due to equipment malfunctions. In 2019, SG launched the "Lianyide" supply-chain service platform, which has enabled seamless connectivity and interactions with resources among upstream and downstream entities within the industrial chain.

As can be observed in Table 5, in 2021, SG was recognized as a "Demonstration Factory for Intelligent Manufacturing of Large-scale Power Equipment" and a "Demonstration Unit for Green Design of Industrial Products" by the Ministry of Industry and Information Technology of the People's Republic of China. Currently, the SG Energy Internet Island stands as an intelligent manufacturing base within the global industry that features the lowest energy consumption per CNY 10,000 of the output value and the lowest amount of emissions. It is capable of generating approximately 380,000 kilowatt-hours of electricity per day through waste heat and pressure energy recovery devices, with the power generation efficiency increased by more than 65%. In 2021, the company successfully implemented a system solution for a steam turbine generator set with the features of "one-button start/stop and unmanned operation" for a power generation project at a steel enterprise in Shandong Province. This implementation saved nearly CNY one million in annual labor costs. In 2024, the AR-based intelligent operation and maintenance system launched by SG enabled an "expert consultation" function. Technical experts can remotely diagnose malfunctioning equipment, thereby increasing the operation and maintenance efficiency by more than 80%. Presently, the proportion of SG's industrial services and operations in total sales orders has reached 80.61%.

Based on the foregoing case analysis and discussions, we put forward the following propositions:

Proposition 4: For manufacturing enterprises with DSCs manifested as service data integration capabilities, the adoption of an ECDS strategy exerts a restraining effect on firm performance.

Proposition 5: For manufacturing enterprises with DSCs manifested in service demand exploration capabilities, adopting an ECDS strategy has an inhibitory effect on corporate performance.

Proposition 6: For manufacturing enterprises with DSCs manifested in digital service orchestration capabilities, adopting an ECDS strategy is instrumental in promoting the improvement of the enterprise's performance.

5. Discussion

Through an in-depth study of three typical manufacturing enterprises, namely, SANY, SG, and SXQC, we reveal the crucial impact of the matching relationship between the DSCs and DS strategy of manufacturing enterprises on their performance. From our results, the three-stage classification of DSCs holds significant theoretical and practical implications. The service data integration capability serves as the foundation for an enterprise's digital servitization. It enables the enterprise to integrate internal and external data resources, construct a comprehensive data network, and thereby gain a comprehensive perception of the market, customers, and products. This comprehensive perception ability provides data support and a decision-making basis for the enterprise's subsequent servitization transformation.

The service demand exploration capability further deepens the enterprise's understanding and insight into customer needs. By leveraging data analysis techniques to convert vast amounts of data into actionable strategies, it enables the accurate identification of—and rapid response to—demands. This is of vital importance for an enterprise's customer-centric product and service innovation.

The digital service orchestration capability represents the core competence of an enterprise in the advanced stage of digital servitization. It involves reallocating resources based on digital technologies, enabling service model innovation and value co-creation, and facilitating the transformation and upgrading of enterprises from traditional manufacturing to service-oriented manufacturing. This three-stage categorization of capabilities represents the application of dynamic capabilities within the context of digital servitization. It also offers a clear roadmap for the development of capabilities in the practice of enterprise transformation.

Concerning the alignment between DSCs and DS strategies at different stages, our results suggest that enterprises in service data integration capability and service demand exploration capability stages exhibit strong compatibilities with PCDS strategies. This finding highlights that, in the initial phase of digital servitization, enterprises should prioritize the digital value addition of the product itself. By enhancing product quality and functionality to meet customers' requirements for the core product value, they can gain a competitive advantage in the market and increase their performance. For example, during the service data integration capability stage, SANY established a data platform to collect and monitor equipment data, which provided support for the intelligent upgrading of products. This, in turn, enhanced the market competitiveness of the products, driving the growth of the enterprise's sales performance and profits. When enterprises develop digital service orchestration capabilities, they can better capitalize on their strengths by aligning with ecosystem-centered digital servitization.

6. Conclusions

This study selected three typical manufacturing enterprises engaged in DS strategies as the research subjects, aiming to explore the mechanism through which the matching relationship between different stages of DSCs and DS strategies in manufacturing enterprises influences enterprise performance. By conducting in-case analysis, cross-case analysis, and longitudinal and horizontal comparisons, three research conclusions were finally derived.

Firstly, grounded in the "Sensing–Seizing–Transforming" framework within the dynamic capability theory, the DSCs are further detailed as service data integration capabilities, service demand exploration capabilities, and digital service orchestration capabilities. Service data integration capabilities highlight that manufacturing enterprises integrate internal and external data resources through technological means. By constructing a data network that encompasses the entire value chain, these enterprises can develop a comprehensive perception of the market, customers, and products. Service demand exploration capabilities refer to the ability of enterprises to extract the patterns of customer needs and business insights from vast amounts of data using data analysis techniques; then, these findings are translated into actionable strategies. The objective is to carry out precise demand identification and provide rapid responses. Digital service orchestration capabilities refer to enterprises reconfiguring resources by leveraging digital technologies, thereby enabling innovation in service models and the co-creation of value.

Secondly, through cross-case comparisons, it has been revealed that as enterprises' capabilities continue to evolve, the DSCs of enterprises as a whole follow a developmental trajectory from service data integration capabilities to service demand exploration capabilities, further progressing to digital service orchestration capabilities. The upgrade path of DSCs can be generalized as a progressive process: from isolated data collection to cross-departmental data fusion, from single-point demand insights to value transformation across the entire value chain, and from internal process optimization to collaborative open ecosystems. This path mirrors the iterative nature of the DSCs of manufacturing enterprises. In accordance with the capability–strategy alignment model, at different DSC stages, manufacturing enterprises need to adopt a corresponding DS strategy to drive performance growth.

Thirdly, based on the three types of DSCs and the two strategic types of digital servitization, six matching modes are identified:

(1) Service data integration capabilities * PCDS strategy;
(2) Service demand exploration capabilities * PCDS strategy;
(3) Digital service orchestration capabilities * PCDS strategy;
(4) Service data integration capabilities * ECDS strategy;
(5) Service demand exploration capabilities * ECDS strategy;
(6) Digital service orchestration capabilities * ECDS strategy.

Among these, both service data integration capabilities and service demand exploration capabilities exhibit a favorable compatibility with the PCDS strategy. By contrast, digital service orchestration capabilities demonstrate a better matching relationship only when paired with the ECDS strategy. Figure 2 depicts the non-linear transition process from service data integration capabilities and service demand exploration capabilities to digital service orchestration capabilities, along with its matching relationship with strategies (PCDS strategy versus ECDS strategy). The area traversed by the red curve represents a positive performance effect. The specific performance manifestations are presented in Table 7.

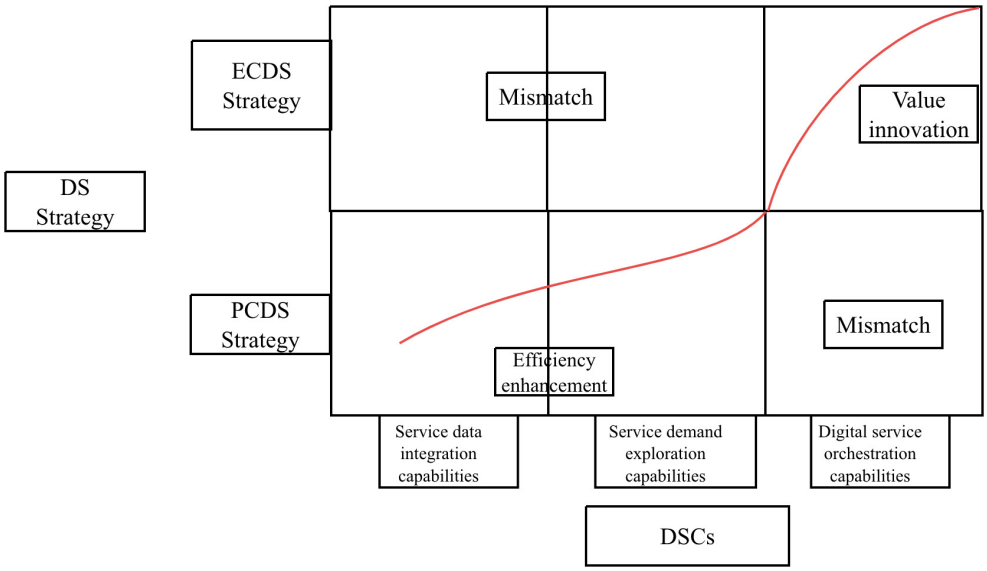

Figure 2. Matching model of DSCs and DS strategy in manufacturing enterprises (The red line indicates the performance of the enterprise).

7. Implications

This study conducted an in-depth analysis of the evolutionary processes of DSCs and DS strategies in three manufacturing enterprises implementing digital servitization, namely, SANY, SXQC, and SG. Based on this analysis, we revealed the dynamic matching relationships between different DSCs of manufacturing enterprises and their DS strategies; moreover, we put forward relevant propositions. The matching relationships between the DSCs and DS strategies of the manufacturing enterprises suggest that only a DS strategy that is well matched with the DSCs of a manufacturing enterprise can more effectively contribute to the enhancement of enterprise performance. More specifically, the following were observed:

① For manufacturing enterprises in the service data integration capability or service demand exploration capability stages, implementing a PCDS strategy can effectively add value to products. This, in turn, enables these enterprises to acquire a competitive edge and increase their performance.

② For manufacturing enterprises at the digital service orchestration capability stage, implementing an ECDS strategy can fully leverage the enterprise's technological advantages in network platforms, giving rise to synergistic effects and thus facilitating improvements in enterprise performance.

The contributions of this study are as follows:

(1) This study goes beyond the abstract expositions of the dynamic capability theory in the domain of manufacturing enterprise servitization. Deconstruct Teece's [26] macro-framework was divided into three-stage dimensions within the context of digital servitization (service data integration capabilities, service demand exploration capabilities, and digital service orchestration capabilities), and through in-depth case-based investigations, we revealed the laws of compatibility between different capability stages and strategies (PCDS and ECDS strategies). This study provides a micro-mechanism interpretation of the dynamic capability theory under manufacturing enterprise digital servitization scenarios.

(2) The digital servitization strategy choice model for manufacturing enterprises constructed in this study (Figure 3) transcends the limitations of traditional servitization research, which typically focuses on static strategy categorizations (such as product-oriented vs. service-oriented strategies). It reveals that an enterprise's digital servitization capabili-

ties (DSCs) adhere to a progressive development law—"service data integration → demand exploration → service orchestration"—thereby driving the dynamic evolution of strategies.

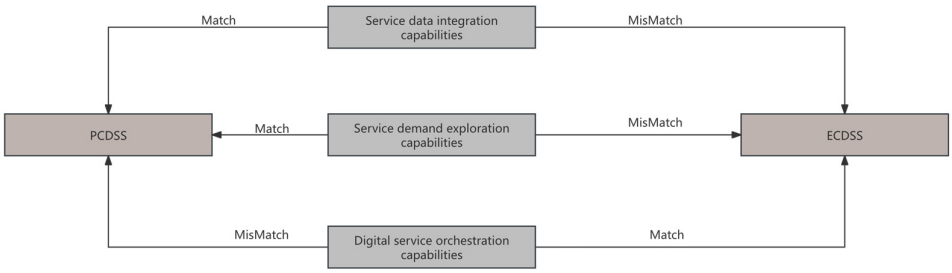

Figure 3. Digital servitization strategy choice model for manufacturing enterprises.

This discovery theoretically presents a fundamental challenge to the traditional "strategy-first" hypothesis proposed by Coreynen et al. [11] and other scholars. It effectively demonstrates the crucial restrictive effect of capability accumulation on strategic feasibility, offering a novel paradigm for understanding the dynamics of digital servitization strategies.

Correspondingly, manufacturing enterprises must discard the inertial "strategy-first" mindset and recognize that strategic choices are restricted by the current DSC level. Enterprises should use their own DSCs as cornerstones and strictly abide by the "capability–strategy" alignment principle. That is, during the foundational product-value-strengthening stage (primarily relying on service data integration capabilities), enterprises should concentrate on basic service guarantees. Once their capabilities progress to the demand exploration stage, they should then focus on identifying and expanding high-value-added service scenarios. Finally, relying on service orchestration capabilities, they can reconstruct their ecological network, resulting in a substantial increase in value.

Only by implementing strategies in a phased and differentiated manner can enterprises effectively avoid the significant risk of misalignment between strategic choices and capability endowments, ensuring the steadiness and success of digital servitization transformations.

(3) This study verifies that the alignment between digital servitization capabilities (DSCs) and strategies is a crucial contingency factor influencing enterprise performance. It reveals the principles of the strategic alignment theory within the context of digital servitization: the effectiveness of digital servitization strategies is strictly constrained by the conditions of digital servitization capabilities.

This discovery directly addresses the question raised by Cimini et al. [9] regarding "when to transition to an ecosystem strategy". Theoretically, it challenges the traditional perception of "strategic universality", highlighting that the capability threshold serves as a prerequisite for dynamic strategic decision making.

Consequently, enterprises urgently need to establish a dynamic strategic adjustment mechanism centered on the assessment of capability thresholds. This mechanism should be capable of diagnosing the alignment status between strategies and capabilities in real time, and the capability threshold should be utilized as the "trigger point" for strategic transitions. By carrying this out, enterprises can establish a dynamic equilibrium that maximizes performance while minimizing risks.

8. Research Limitations and Future Prospects

This study, based on the analysis of three manufacturing enterprises, presents a model encompassing DSCs, DS strategies, and performance. Nevertheless, the proposed model and propositions are subject to certain limitations. These limitations necessitate

further verification, refinement, and improvement through the use of large-sample data and empirical research methods. Specifically, a more comprehensive and in-depth analysis using a substantial amount of data could help validate the generalizability and accuracy of the model. Secondly, given enterprise, scale, and business model variations, there are disparities in both the willingness of enterprises to embark on digital servitization transformation and the extent to which such transformations are carried out. Consequently, it is imperative to conduct further investigations into the impact of digital servitization transformation on performance across different types of enterprises. Additionally, exploring which DSCs are most appropriate for aligning with these various enterprise types is also of great significance.

In the future, manufacturing enterprises are advised to further elaborate on their DSC indicator systems. They can develop enterprise-specific SaaS tools, define indicator thresholds, and monitor capability thresholds in real time (e.g., data utilization rate, management expense ratio, etc.). Moreover, these enterprises can automatically generate diagnostic reports and provide strategic recommendations for enterprise managers or government reviewers, thereby reducing trial-and-error costs.

The government can formulate differentiated policies according to the capability gaps of enterprises in different regions. For example, in areas with low-level digital servitization, product strategy training can be implemented to accelerate regional digital servitization transformations.

Our research findings can be extended to other industries, such as consumer goods and pharmaceuticals. By validating the universality of the conclusions through large-scale sample data, more robust evidence can be provided for industry associations to establish maturity standards.

Author Contributions: Conceptualization, J.C. and L.Z.; methodology, H.D.; software, L.Z.; validation, H.D. and L.Z.; formal analysis, J.C.; investigation, L.Z., J.C. and H.D.; resources, J.C.; data curation, L.Z. and H.D.; writing—original draft preparation, L.Z.; writing—review and editing, J.C.; visualization, H.D.; supervision, J.C.; project administration, J.C.; funding acquisition, J.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Social Science Fund of China grant number [22BTJ050] and The APC was funded by the National Social Science Fund of China.

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to (confidentiality clauses in research agreements with participating enterprises (SANY, SXQC, SG)).

Conflicts of Interest: The authors declare no conflict of interest.

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