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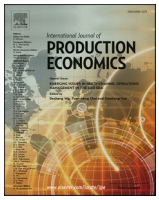

Digital servitization in digital enterprise: Leveraging digital platform capabilities to unlock data value

Yibo Jia [a], Li Cui [b], Jingqin Su [a], Lin Wu [c], Shahriar Akter [d,*], Ajay Kumar [e]

[a] School of Economics and Management, Dalian University of Technology, Dalian, China
[b] Business School, Dalian University of Technology, Panjin, China
[c] Nottingham University Business School, University of Nottingham, Nottingham, UK
[d] Faculty of Business & Law, University of Wollongong, Australia
[e] EMLYON Business School, Lyon, France

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ABSTRACT

Existing research has not clearly defined digital platform capabilities or explained how they unlock data value, limiting the understanding of digital servitization in digital enterprises. Therefore, our study draws upon the Dynamic Capability Theory and employs an exploratory, in-depth single case study approach to bridge this research gap. We identify three key digital platform capabilities: data integration capability, data analytics capability, and data productization capability. Our results demonstrate that these capabilities function as "reservoirs," "catalysts," and "pipelines" in a specific iterative sequence to unlock data value, thereby facilitating the successful implementation of digital servitization in digital enterprises. Furthermore, these capabilities are interconnected, collectively forming a dynamic capability—digital platform capability—that unlocks data value by integrating and reconfiguring data resources. Additionally, we delineate the differences in digital servitization between digital enterprises and traditional manufacturers across three dimensions: motivation, key service design activities, and benefits. Our findings enrich the existing literature on digital platform capabilities and data value while expanding the research scope of digital servitization from the perspective of digital enterprises.

1. Introduction

With the growing application of emerging digital technologies and fluctuating customer demands, digital servitization has become a crucial strategic decision for enterprises. These technologies are leveraged to achieve incremental benefits and establish more durable competitive advantages (Struwe and Slepniov, 2023; Chirumalla et al., 2023; Shen et al., 2023; Vendrell-Herrero et al., 2022). Digital servitization involves transforming processes, capabilities, and offerings within enterprises to create, capture, and deliver enhanced service value enabled by various digital technologies (Sabrina et al., 2023; Shen et al., 2023; Paschou et al., 2020). More recently, the phenomenon of digital servitization in digital enterprises such as Amazon, Cargo One, and Alibaba has been highlighted (Eloranta et al., 2021; Fu et al., 2022; Jia et al., 2023). Digital enterprises are characterized by their substantial use of digital resources, such as software, algorithms, and data, and/or by their selling of a large array of digital products and services (e.g., software and media) (Giustiziero et al., 2023; Hellwig, 2022). In contrast to traditional manufactures, these digital enterprises perceive data as a pivotal starting point for advanced services and the creation of customer value (Jovanovic et al., 2022; Giustiziero et al., 2023). Specifically, they can continuously create and deliver advanced services for customers by adeptly leveraging digital technologies, such as artificial intelligence (AI) platforms, to integrate, transmit, and develop extensive data beyond the company's immediate scope (Wamba et al., 2021; Mosch et al., 2023; Favoretto et al., 2022). For instance, Merchants Fleet collects and analyzes key vehicle data, including location, fuel consumption, and maintenance history. These data enable the company to offer fleet management services, thus enhancing the efficiency of the fleets of customers. Consequently, digital enterprises are increasingly recognized as pivotal drivers and practitioners of digital servitization (Liu et al., 2023).

Remarkably, the existing literature on digital servitization in digital enterprises remains limited. Empirical research has predominantly

* Corresponding author.
E-mail addresses: jiayibo@dlut.edu.cn (Y. Jia), cuili@dlut.edu.cn (L. Cui), jingqin@dlut.edu.cn (J. Su), lin.wu@nottingham.ac.uk (L. Wu), sakter@uow.edu.au (S. Akter), akumar@em-lyon.com (A. Kumar).

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focused on the digital servitization of traditional manufacturers (Kohtamäki et al., 2019; Paschou et al., 2020; Tronvoll et al., 2020), with digital enterprises receiving insufficient attention. These facts suggest that digital enterprises exemplify the successful implementation of digital servitization by extensively leveraging data resources and digital technologies (Liu et al., 2023; Yan et al., 2022). Studying the digital servitization of digital enterprises can unlock valuable lessons and insights for other enterprises facing similar contexts. Additionally, the concept of data value is currently generating substantial discussion within the digital servitization framework. Most scholars have recognized that data, as a foundational and transformative resource, can provide considerable value to both customers and enterprises in successful digital servitization. Services include offering decision support, creating new business models, and realizing intelligent services (Opresnik and Taisch, 2015; Eggert et al., 2022; González Chávez et al., 2024). In other words, data value has proven to be a key objective for digital enterprises to successfully implement digital servitization and remain competitive (Chen et al., 2023; Yan et al., 2022). However, the literature also suggests that data do not have direct application value (Boldosova, 2020; Mortati et al., 2023). Both empirical and theoretical studies have demonstrated that enterprises can only unlock the value embedded in data after multiple complex steps of collection, processing, and analysis, which in turn support digital servitization (Saggi and Jain, 2018; Kohtamäki et al., 2020). This highlights the increasing challenge associated with unlocking data value (Günther et al., 2017). Moreover, large, diverse, and complex data are generated by users interacting with digital products and services (Mortati et al., 2023). This Big Data phenomenon further hinders the process of unlocking data value, even for digital enterprises with digital technologies related to data (Crte-Real et al., 2020; Giustiziero et al., 2023).

A growing body of empirical research focuses on digital platforms, particularly AI platforms, emphasizing their potential for unlocking data value in digital enterprises (Eloranta et al., 2021; Liu et al., 2023; Tian et al., 2022; Jovanovic et al., 2022; Struwe and Slepniov, 2023). For example, Wamba et al. (2021) stressed that AI-based platforms enable companies to better collect, store, organize, and analyze data, thus providing data-driven, proactive services. However, merely viewing digital platforms as a critical digital infrastructure is insufficient; digital enterprises must also have the capability to leverage digital platforms to address the complexity and diversity of data. This contributes to unlocking data value and advancing digital servitization (Jovanovic et al., 2022; Wang et al., 2023a,b). Consequently, leveraging digital platform capabilities to unlock data value has become crucial for the successful implementation of digital servitization in digital enterprises (Struwe and Slepniov, 2023; Chen et al., 2023). Despite the growing scholarly interest in digital platform capability as a higher-order dynamic capability (Liu et al., 2022a,b; Wang et al., 2023a,b), research into such capabilities, especially in the context of digital servitization, is still in its infancy. This gap has limited the understanding of the specific digital platform capabilities required to unlock data value (Lenka et al., 2017). Furthermore, recent literature has called for contributions to enhance the understanding of how digital platform capabilities facilitate the unlocking of data value for the successful implementation of data servitization (Favoretto et al., 2022). To deepen the understanding of digital servitization in digital enterprises, the following research questions are proposed to address these key theoretical gaps.

(1) *What digital platform capabilities are necessary to unlock data value in the context of digital servitization?*
(2) *How can digital platform capabilities unlock data value to enable digital enterprises to successfully implement digital servitization?*

To address these research questions, dynamic capability theory is used and an in-depth case study approach is adopted, focusing on a digital enterprise in China. While a single case study may limit the generalizability of findings, its primary purpose is to offer new insights and guideposts for the successful implementation of digital servitization in similar contexts. This study makes three key theoretical contributions. First, from the perspective of digital enterprises, a new concept of digital servitization is proposed in response to the call of Kowalkowski et al. (2017) to expand the research boundaries of digital servitization. Drawing from three dimensions, namely motivation, critical service design activity, and benefit, this study illustrates the differences in digital servitization between digital enterprises and traditional manufacturers. This illustration provides a valuable starting point for further explorations of digital servitization practices in digital enterprises. Second, this study advances research on digital platform capabilities. Compared to previous research on digital capabilities (Chen et al., 2023; Faroukhi et al., 2020; Li et al., 2022; Ferraris et al., 2019), three digital platform capabilities are conceptualized and their interdependence is demonstrated. This contributes to a more nuanced understanding of the structure and content of digital platform capabilities (Annarelli et al., 2021; Mikalef et al., 2019; Parvinen et al., 2020). More importantly, this study discloses the different roles these capabilities can play in unlocking data value because of the characteristics of digital platforms, thereby aiding the successful implementation of digital servitization in digital enterprises. These insights address the call of Annarelli et al. (2021). Third, this study identifies that digital platform capabilities can effectively unlock data value by playing three roles in a specific iterative order, thereby expanding the literature on data value (Ren et al., 2023; Paiola and Gebauer, 2020; Paschou et al., 2020).

2. Theoretical background

2.1. Digital servitization

The debate surrounding digital servitization over the past decade has highlighted the convergence of two key research streams: servitization and digitalization (Paschou et al., 2020; Favoretto et al., 2022; Wang et al., 2023a,b; Shen et al., 2023). First introduced by Vandermerwe and Rada (1988), servitization describes a shift in organizations from focusing solely on goods or services to offering service-led "bundles". Currently, research on servitization increasingly emphasizes leveraging technologies, particularly digital technologies, to develop solutions for contextual problems and create value-in-use (Gebauer et al., 2021; Liu et al., 2023). Indeed, scientific evidence indicates that the application of novel digital technologies, such as Industry 4.0 technologies, cloud computing, and AI, can further support servitization by enabling more sophisticated and innovative offerings, thereby reshaping competition in the industry (Ardolino et al., 2018; Rad et al., 2022; Paschou et al., 2020). Therefore, digital technologies pave the way for new services through digitalization, leading to digital servitization (Kohtamäki et al., 2019).

Despite the growing practical and theoretical interest in the development of digital servitization, the concept remains at the exploratory stage and lacks a universally accepted definition (Paschou et al., 2020). Overall, research on the concept of digital servitization can be categorized into two main directions, as shown in Table 1. The first direction focuses on the technology perspective, emphasizing value creation enabled by servitization through digital technologies (Paschou et al., 2020; Vendrell-Herrero et al., 2021). From this perspective, digital servitization emphasizes the role of digital technologies in creating and appropriating value from product-service offerings (Vendrell-Herrero et al., 2017; Sabrina et al., 2023). The second direction takes an organizational perspective and emphasizes the transformational process (Shen et al., 2023). This research direction identifies digital servitization as a transformational process where an organization shifts from a product-centered to a service-centered business model, taking advantage of digital technologies (Tronvoll et al., 2020; Kohtamäki et al., 2019).

Existing research primarily focuses on traditional manufacturing companies, while the literature on digital servitization directs little to no

Table 1
Definitions of digital servitization.

Categories	Definitions of digital servitization	Author(s)
Technology perspective	The development of new services and/or the improvement of existing services through the use of digital technologies.	Paschou et al. (2020)
	The transition towards smart solutions (product-service-software systems) that enable the creation and capture of value through monitoring, control, optimization, and autonomous functions.	(Sabrina et al., 2023)
	Digital servitization focuses on how digital technology enables the supply of services in innovative ways.	Paiola and Gebauer (2020)
	The provision of IT-enabled (i.e., digital) services relying on digital components embedded in physical products.	Vendrell-Herrero et al. (2017)
Organization perspective	The utilization of digital tools for transformational processes whereby a company shifts from a product-centric to a service-centric business model and logic.	Kohtamäki et al. (2019)
	Technology-enabled business models that enable companies to gain the competitive advantage by providing digital services based on customer knowledge throughout the product life cycle.	Bustinza et al. (2018)
	The provision of digital services, embedded in physical products, offers opens up possibilities for new business models and welcomes new entrants.	Rymaszewska et al. (2017)
	The transformation in processes, capabilities, and offerings within industrial firms and their associated ecosystems to progressively create, deliver, and capture increased service value arising from a broad range of enabling digital technologies.	Sjödin et al. (2020)

attention to digital enterprises (Kohtamäki et al., 2019). In contrast, digital servitization is more common among digital enterprises (e.g., Amazon, Airbnb, and Microsoft) in the era of the digital economy (Struwe and Slepniov, 2023; Yan et al., 2022). Digital enterprises are characterized by a substantial share of digital resources, such as software, algorithms, and data, or by the provision of a substantial range of digital products and services (e.g., software and media) (Giustiziero et al., 2023). These enterprises often operate on internal digital platforms, possess a deeper understanding of the characteristics and usage of various emerging digital technologies, and can leverage these technologies to optimize and improve their digital products (e.g., software and applications) and Internet services. As a result, they continuously create novel experiential value for customers (Mosch et al., 2023; Giustiziero et al., 2023; Jia et al., 2023). In other words, digital enterprises provide a quintessential example of digital servitization and are alternatively referred to as digital service providers (Struwe and Slepniov, 2023). Therefore, there is a need to enrich the digital servitization literature from the perspective of digital enterprises. As noted by Kowalkowski et al. (2017), digital servitization is not confined to traditional manufacturers.

2.2. Data value in digital servitization

Recent studies increasingly emphasize the pivotal role of data in the success of digital servitization (Opresnik and Taisch, 2015; Eggert et al., 2022). Rather than competing solely for incremental product improvements, data has emerged as a key enabler for both novel service offerings and innovative business models (Rymaszewska et al., 2017; Tronvoll et al., 2020). However, the definition of data value remains inadequate. Certain scholars suggested that data value pertains to the application value of data products, the benefits and competitive advantages data brings to organizations, and the positive societal outcomes that drive human development (Fosso et al., 2015; Ehret and Wirtz, 2017; Günther et al., 2017). Specifically, digital technologies such as cloud computing, the Internet of Things (IoT), and data analytics offer enterprises the opportunity to extract more value from massive amounts of data (Eggert et al., 2022; Ji-fan Ren et al., 2017).

In the context of digital servitization, scholars have extensively explored the value data contributes to enterprises across various dimensions, including production, research and development, strategy, and marketing. For manufacturing enterprises, reasonable use of data can enhance the effectiveness, intelligence, and security of production systems (Favoretto et al., 2022; Wang et al., 2023a,b; Bilgeri et al., 2019; Opresnik and Taisch, 2015; Liu et al., 2022a,b). For instance, Boldosova (2020) argued that the management of product data through sensors enables real-time monitoring of a product's movement, condition, and performance, thereby optimizing product performance and enhancing customer experience. In the research and development sector, enterprises can accelerate the prototype design cycle and innovate continually by establishing data-driven innovation models (Sestino et al., 2020; Sultana et al., 2021). From a strategic perspective, data analysis can help organizations to gain insights into their business operations, and historical data can aid in predicting current and future trends, thereby supporting decision-making and strategic planning (Sestino et al., 2020). Similarly, existing research highlighted that enterprises can identify and predict customer behavioral patterns through multi-dimensional correlation analyses of various types of customer data. These capabilities enable them to respond promptly to market demands and offer advanced services, such as preventive and predictive maintenance (Zhou et al., 2021).

In the context of digital servitization, unlocking data value has proven to be a challenging task (Faroukhi et al., 2020). First, raw data from devices, platforms, and sensors lack direct application value (Boldosova, 2020; Günther et al., 2017). The transformation of raw data into valuable knowledge or data products is only achievable after completing essential steps such as collection, storage, processing, analysis, application, and others (Saggi and Jain, 2018; Li et al., 2020; Kohtamäki et al., 2019). In this context, unlocking data value is considered an 'expensive exercise' (Gebauer et al., 2020). Second, the application of digital technologies such as IoT, blockchain, and AI has led to exponential growth in massive multi-source heterogeneous data every second (Opresnik and Taisch, 2015; Sultana et al., 2021). The ongoing proliferation of large, diverse, and complex data makes it increasingly challenging for enterprises to manage and utilize data using conventional technologies (Ren et al., 2023; Boldosova, 2020; Ehret and Wirtz, 2017; Li et al., 2020). As a result, the Big Data phenomenon has substantially hindered the process of unlocking data value related to servitization, even for digital enterprises already offering data products and services (Crte-Real et al., 2020; Giustiziero et al., 2023; Favoretto et al., 2021). Although existing literature suggests that advanced digital technologies are beneficial for extracting potential value from data (Tronvoll et al., 2020; Ren et al., 2023; Paschou et al., 2020; Paiola and Gebauer, 2020), guidance on how enterprises, especially digital enterprises, can leverage digital technologies for data management, creation, and ultimately unlocking data value remains limited (Crte-Real et al., 2020).

2.3. Digital platform capabilities in digital servitization

The digital servitization literature has explored the potential of digital platforms to enable broader product-service applications (Liu et al., 2023; Jovanovic et al., 2022; Tian et al., 2022; Cenamor et al., 2017). In the context of digital servitization, digital platforms represent a more complex form of digital technology (Cenamor et al., 2019).

Digital platforms are understood as interconnected electronic business processes and technology applications supported by data (Madanaguli et al., 2023). Importantly, these digital platforms predominantly refer to industrial service platforms, also known as servitization platforms, rather than to e-commerce platforms (Eloranta et al., 2021). Recent research has confirmed that successful digital servitization strongly depends on the development of digital platform capabilities (Struwe and Slepniov, 2023; Kohtamäki et al., 2019; Eloranta et al., 2021). However, by themselves, digital platforms are not sufficient as a source of competitive advantage; the potential value of digital platforms can only be fully realized when they are embedded in organizational capabilities (Wang et al., 2022). Hence, using dynamic capability theory helps to achieve a deeper understanding of the core function of the digital platform to maintain a sustainable competitive advantage in the digital era (Liu et al., 2022a,b). Although digital platform capability is often considered a higher-order dynamic capability (Liu et al., 2022a,b; Wang et al., 2023a,b), its comprehensive definition is still in its early stages. Certain scholars argued that digital platform capabilities refer to "the technical competence of firms' digital platforms to integrate and deploy internal and external resources of enterprises" (Cenamor et al., 2019; Xiao et al., 2020; Wang et al., 2022).

There are various dimensions of digital platform capability (Wang et al., 2023a,b; Cenamor et al., 2019). For instance, Cenamor et al. (2019) proposed the two categories of digital platform integration capability and digital platform reconfiguration capability. While the former focuses on the platform's internal communication and coordination skills, the latter adopts an external perspective, emphasizing the ability of the platform to manage external relationships and access external resources (Cenamor et al., 2019; Liu et al., 2022a,b). Moreover, other literature categorized digital platform capabilities based on different target markets, distinguishing between capabilities for consumers and those for businesses (Karimi and Walter, 2015; Wang et al., 2022).

There is growing interest in the impact of digital platform capabilities on unlocking data value in the context of digital servitization (Tian et al., 2022; Jovanovic et al., 2022; Struwe and Slepniov, 2023). For instance, Tian et al. (2022) explained that digital platforms enable organizations to better capture and manage data, thereby facilitating both incremental and radical service innovations. Similarly, Jovanovic et al. (2022) highlighted the role of digital platforms in collecting operational and equipment data as well as conducting analytics to enable more advanced services. However, existing research has provided limited insights into what constitutes digital platform capabilities (Lenka et al., 2017), making it challenging for digital enterprises to determine the necessary capabilities that effectively unlock data value. In addition, the literature has emphasized the importance of developing data-related capabilities for successful digital servitization (Kohtamäki et al., 2019; Momeni et al., 2023; Giustiziero et al., 2023). Nevertheless, how digital platform capabilities unlock value to drive digital enterprises in achieving digital servitization is still open for examination.

3. Methodology

A single in-depth case study approach was deemed most appropriate for this study. First, according to Eisenhardt and Graebner (2007), the case study method is suitable when examining exploratory "how" questions, which is the objective of this study. Second, during the literature review process, a limited number of existing studies were found, indicating a need to develop new theoretical insights from a chosen case, thus enriching the emerging literature on digital platform capability and digital servitization (Struwe and Slepniov, 2023; Yan et al., 2022). Third, the single in-depth case study approach is particularly suitable for situations requiring deep immersion in the research context, multiple sources of evidence, and a rich description of the focal phenomenon in a real-life social setting (Piepponen et al., 2020). Compared to other qualitative methods, this approach can provide richer and more systematic contextual information, thus contributing to a deeper understanding of the digital servitization of the case enterprises and generating relevant insights (Klein and Myers, 1999; Jia et al., 2023). Therefore, the chosen method is considered appropriate for this study (Mosch et al., 2023; Rymaszewska et al., 2017).

3.1. Case selection

Considering the research objective, theoretical sampling was employed to select the case enterprise. The Chinese digital enterprise Mars (pseudonym) was chosen for this study.

First, Mars represents an extreme case that is both typical and representative of the phenomenon of digital servitization (Gerring 2007, p. 101). As China's leading digital service provider, Mars has been involved in the e-government field since 2002 and it is one of the earliest enterprises to promote the construction of the "digital government" in China. The e-government in China has consistently aimed to enhance the intelligence of government services across various business scenarios through the use of digital technologies. Currently, Mars is data-driven and has provided high-quality, efficient, and secure service offerings and solutions for governmental customers in over 20 application scenarios; these scenarios include emergency management, social governance, taxation, production safety, and natural resources. As of 2022, the services scope of this digital enterprise has covered more than 100 cities and 800 counties in China, earning recognition as one of the "Top Ten Digital Government Model Projects" and "Outstanding Achievements in Digital Government".

Second, Mars prioritizes the unlocking of data value. To fully unlock data value for government customers, Mars has developed various digital platforms, such as the "Industry Digital Platform", "Data Security Control Platform", and "Domain-wide Knowledge Service Platform", using AI, cloud computing, and other digital technologies. Leveraging these digital platforms, Mars can assist its customers from government in efficiently completing tasks such as the collection, management, security, and analysis of data, thereby enhancing the quality of public services and social governance for government customers. Therefore, this practical information can offer new theoretical insights to deepen the available understanding of the dimensions and content of digital platform capabilities.

Three, this study adheres to the principle of data accessibility. A long-term relationship with Mars has been established, making the digital enterprise willing to provide a wealth of primary data.

3.2. Data collection

During the data collection process, triangulation of data sources was ensured to enhance the reliability of the results (Cui et al., 2019). To strengthen the credibility collected data, data triangulation involves comparing data gathered from various sources, such as secondary archival data and primary interview data from multiple respondents (Yin, 2009: p. 144). The data collection process used three stages. Initially, before conducting field interviews, secondary data were collected from official websites, books, and annual reports. Moreover, numerous relevant videos were reviewed, including news reports and documentaries. As a successful example, open information on Mars is abundant and easily accessible. Through this process, a preliminary understanding of the case company' background information in the industry was obtained and the company's suitability for this study was confirmed.

The second stage involved conducting field interviews. From August 2021 to November 2023, semi-structured interviews were carried out with seven top managers at Mars to gather detailed information about the company's digital servitization efforts. These seven interviewees were identified through secondary sources and preliminary interviews, a practice that corresponds to the snowball sampling method commonly used in case study research (Cui et al., 2017). The main process of the

snowball sampling method involved the initial interviews of two key individuals, namely the president and chief executive officer of Mars, in which they were asked to recommend other participants. These participants included a senior product manager, human resource manager, and a chief technology officer. This method enabled the screening of suitable interviewees within a relatively short period and facilitated the establishment of trust, thereby enhancing the acquisition of accurate and reliable interview data (Yin, 2009). During the interviews, participants were invited into a meeting room, where the research objectives were introduced, and they were provided with the outline of the interview. All interviews were carefully transcribed and translated, resulting in a comprehensive document exceeding 300 pages, which included over 217 photos and 134 pages of notes. Furthermore, other internal and external data were collected to verify or complement the interview data. Table 2 outlines the data collection process.

To further ensure the reliability of the results, multiple investigators were engaged in the data collection process to minimize potential subjective bias caused by researchers. Information gathered by different investigators was meticulously compared, and efforts were made to achieve consensus when conflicting perspectives emerged on specific issues. For instance, following disagreements among investigators regarding the role of digital platforms in the digital servitization process during the initial round of interviews, subsequent interviews were conducted focusing specifically on digital platform capabilities. Later, investigators pursued specific follow-up questions (using WeChat) targeting key informants such as the president and chief executive officer, who are considered more knowledgeable in overall organizational management. Table 3 presents the applied interview protocol.

3.3. Data analysis

A single in-depth case study aims to 'tell a good story', while systematically conceptualizing a certain phenomenon. Data analysis followed the rigorous encoding method (Gioia et al., 2013). Initially, 1st-order analysis involved identifying and utilizing empirical codes and terms from raw data, resulting in 17 first-order categories, including "Data is stored in several ordered sub-databases" and "Knowledge modules can be invoked by Mars at any time in different application scenarios". These first-order categories were all expressed in the original language used by the interviewees. To avoid excessive reliance on interview data, all emerging first-order categories were cross-checked against other sources of information (Huang et al., 2021). Subsequently, the principles and techniques of axial coding were applied for the 2nd-order analysis, to group first-order concepts with similar theoretical connotations into higher-order conceptual constructs (theory-centric). This grouping involved a constant switch between different levels of tentative understanding of already identified first-order categories in terms of connections and meanings; this culminated in a saturation point and the conceptualization of 9 s-order themes, including "Data standardization" and "Knowledge modularization". Finally, these second-order themes were further abstracted into four aggregated dimensions. The process of forming these dimensions followed the same approach described for second-order themes. Throughout the coding process, emerging categories and themes from the collected data were consistently iterated with relevant literature, thus allowing researchers to relate and classify concepts based on their empirical and theoretical substance (Huang et al., 2017). Fig. 1 illustrates the data structure.

In an attempt to triangulate the coding process, three researchers performed the coding using Nvivo 13 software. Every emerging code was questioned and discussed until consensus was reached regarding the alignment of theory and data (Pan and Tan, 2011). The results of this data analysis were also shared with the interviewees and other researchers for comments and were not finalized until a consensus was achieved.

Table 2
Data collection.

Data sources	Interviewees/ Archives	Lengths (min)	Transcriptions
Semi-structured interviews (D1)	President	110	14,000 words transcribed
	Chief executive officer	170	28,000 words transcribed
	Senior product manager	120	15,000 words transcribed
	Human resource manager	190	28,500 words transcribed
	Data governance Department manager	300	42,000 words transcribed
	Chief technology officer	120	19,000 words transcribed
	Client engagement manager	70	9800 words transcribed
	Dean of the business school	90	12,000 words transcribed
Internal data (D2)	Managers' speeches, conference videos, corporate website materials, and company publications		10 h of video materials and 34 pieces of written materials (260,000 words transcribed)
External data (D3)	News reports, social media publicity materials, and case studies		11 industry reports, 2 case studies, and 27 web reports (37,000 words transcribed)

Table 3
Interview questions (selection).

Interview stages	Interview questions
Initial interview stage	1. What are the key development points and important events of Mars? 2. What are the core products/services of Mars? 3. What demands are government customers placing on Mars? 4. What impact do Mars's services and solutions have on customers? 5. What are the advantages of implementing digital servitization in Mars?
Field interview stage	1. What platforms have been developed by Mars in the process of implementing digital servitization? 2. What are the core competencies of Mars's digital platforms? 3. What are the connections between these digital platforms? 4. How do these digital platforms collect data? 5. How do these digital platforms govern data? 6. How do these digital platforms secure data? 7. How do these digital platforms mine knowledge from massive data? 8. What challenges does Mars face in unlocking data value? How does the company overcome these challenges? 9. What value are Mars's service offerings bringing to government customers? 10. How have the digital service offerings of Mars changed? 11. What are the differences in service offering demanded by government customers in different sectors? 12. How does Mars apply AI in the process of implementing digital servitization?
Later interview stage	1. Why do companies need to modularize their knowledge? 2. What benefits does knowledge modularization bring to Mars's digital servitization? 2. What application scenarios have Mars's service products been used in?

4. Research results

4.1. Identification of capabilities

Building on empirical data from case companies, this study identifies the demand of government customers for "integrated operations" in the process of developing "digital government". The term "integrated operations" emphasizes the establishment of an operational model for data

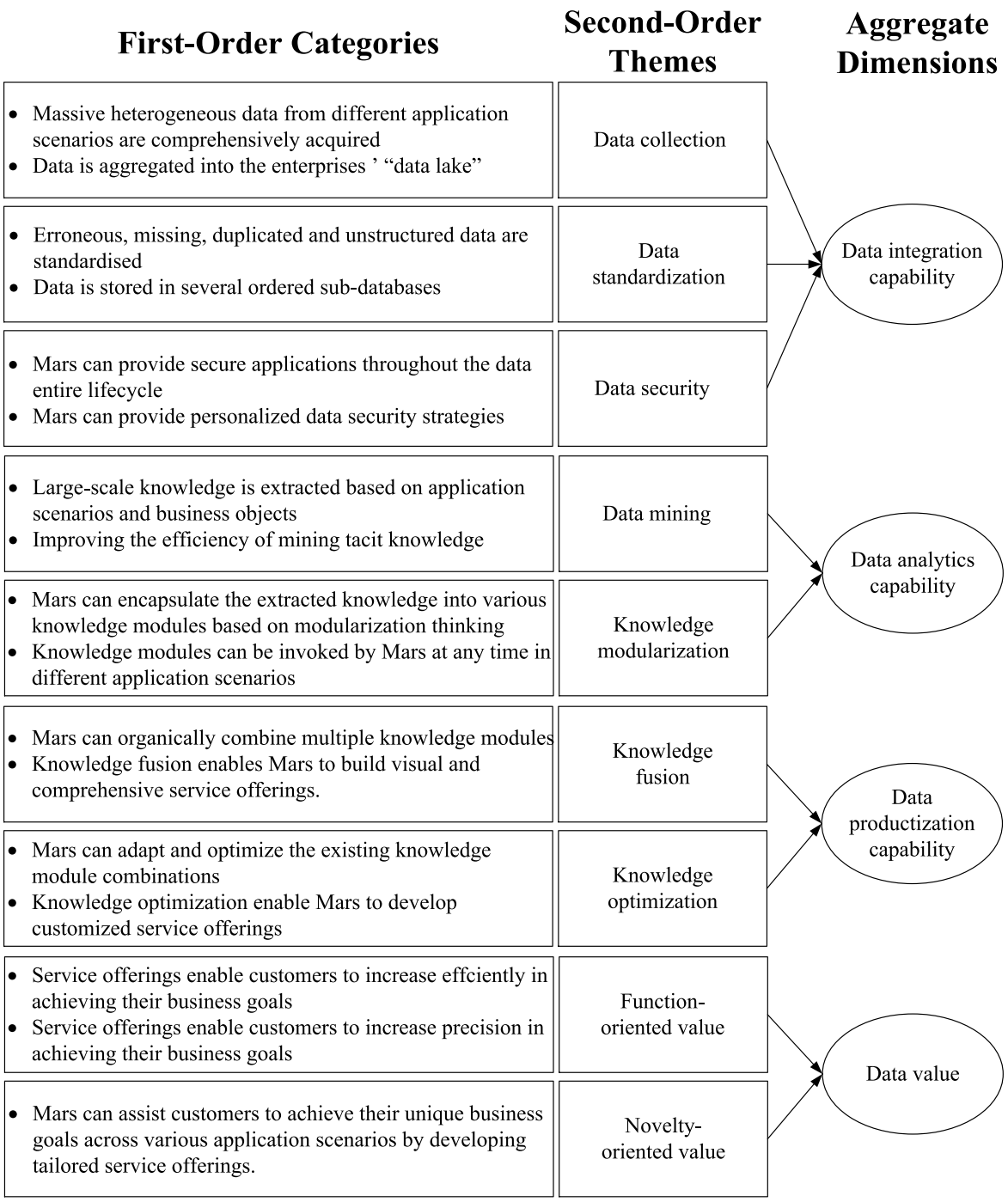

Fig. 1. Data structure.

sharing, information interaction, and business collaboration. This is achieved by consolidating the disparate business systems of various governmental departments onto a unified digital platform or application software. This model enables governmental departments to offer diverse, efficient, and convenient online services to the public, thereby advancing the digital transformation and service innovation of government customers. Arguably, the core purpose of "integrated operations" is to fully utilize data value, thus facilitating the achievement of business goals such as emergency command, public service, and social governance across various application scenarios (Haug et al., 2023). Consequently, Mars has initiated digital servitization to provide government customers with solutions that unlock data value, ultimately meeting their "integrated operations" demand. However, in this process of unlocking data value, Mars has encountered various challenges requiring the utilization of digital platform capabilities to formulate an effective response. The structured coding and analysis results identified three distinct capabilities: data integration capability, data analytics capability, and data productization capability, all of which are detailed in the following.

4.1.1. Data integration capability

When implementing digital servitization, the unlocking of data value for government customers necessitates the extensive acquisition and management of raw data within specific application scenarios. However, raw government data are characterized by high volume, variety, and security risks (Saggi and Jain, 2018), posing a data complexity challenge

for Mars. To address this challenge, Mars has leveraged its data integration capability, which refers to the ability to collect, govern, and secure massive heterogeneous data. The analysis exposed three sub-themes. Table 4 shows the evidence of data integration capability.

First, the data collection theme denotes the ability to gather massive amounts of heterogeneous data from various sources and store them in a data warehouse. Through the "IoT Sensing Platform", Mars can comprehensively collect these massive government data across diverse application scenarios such as public services, the ecological environment, urban management, and social governance. These raw government data originate from business systems, terminals, sensors, government Apps, and public information on the Internet, and are ultimately aggregated into Mars's "data lake" through a unified API interface.

Second, the data standardization theme involves the capacity to clean, standardize, and classify the collected raw data. Mars employs the "Industry Digital Platform" and digital technologies such as erasure coding and data validation tools to cleanse and convert erroneous, missing, duplicated, and unstructured government data, thereby achieving data standardization. Additionally, Mars established 154 data classification rules to systematically organize raw government data in the "data lake" into various sub-databases based on government business attributes. These sub-databases primarily encompass foundational, thematic, specialized, and tag databases.

Table 4
Representative quotations for each theme of data integration capability.

Digital platform capabilities	Themes	Representative quotations
Data integration capability	Data collection	● Enabled by the digital platform, Mars has helped the China Forestry Big Data Centre to collect more than 80 million forestry data and more than 5 pb of unstructured data. (D3) ● In the "Smart J City" project, data can be simultaneously aggregated from 1137 5G base stations, 260,000 cameras, and 292 car parks by leveraging digital platforms. (D1) ● Mars is currently planning to introduce AIGC technology to further enhance the massive data storage capability of the digital platform. (D1)
	Data standardization	● Mars has provided governance of tax data in Province S, resulting in more than 98% governance coverage and more than 99% data accuracy. (D2) ● Mars has 10 years of data standardization experience and can leverage digital platforms to rapidly improve the accuracy, consistency, and integrity of raw data. (D1) ● The "Industry Digital Platform" works like a data processing plant, which can provide our customers with high-quality data standardization and intelligent testing services. (D1)
	Data security	● The "Data Security Control Platform" enables enterprises to realize highly secure and controllable data security query, governance, and application. (D1) ● Based on digital platforms, Mars has improved the data security capabilities of the H Provincial Emergency Department from multiple aspects such as development and operation. (D2) ● Mars has also collaborated with a leading data technology service provider in China to jointly develop a data desensitization solution (InfoMask) based on digital platforms, in order to maximize the protection of customer data security. (D1)

Third, the data security theme represents the ability to effectively monitor and safeguard the privacy of raw government data. For example, by leveraging the "Data Security Control Platform" and digital technologies such as Trusted Blockchain, Cloud Cryptography, and Privacy Computing, Mars offers government customers security solutions across the entire data lifecycle. These solutions include data security situational awareness, secure data sharing, basic platform security, and personalized data security strategies. Additionally, Mars leverages the "Data Privacy Protection Platform" and technologies like Secure Multi-Party Computation and cryptography to implement multi-dimensional data desensitization rules and algorithms, along with a strict access management mechanism. These measures ensure a balance between extensive data collection and effective data privacy management. The chief technology officer explained the following:

> "*We have built a targeted data security system for the C Provincial Emergency Bureau, covering multiple stages including development and operation, which in turn has achieved the protection of more than 200 categories of more than 300 million pieces of data.*"

In summary, to address the data complexity challenge, Mars has leveraged its data integration capability to collect, govern, and secure data. This capability enhances the comprehensiveness, standardization, and security of raw government data, which is then systematically stored in the "data lake". The details of the digital integration capability are illustrated in Fig. 2. Based on this, the first proposition is suggested.

P1. In the context of digital servitization, data integration capability, including data collection, data standardization, and data security, enables digital enterprises to enhance the comprehensiveness, standardization, and security of raw data, thereby helping to address the data complexity challenge.

4.1.2. Data analytics capability

The cornerstone of data value lies in actionable knowledge, which includes facts, concepts, relationships, patterns, experiences, or methods that can be directly used to solve practical problems (Wei et al., 2019; Günther et al., 2017). Thus, based on integrating raw government data, Mars began to extract knowledge from massive data under specific application scenarios. However, Mars observed that government customers often require knowledge spanning multiple application domains to achieve their business goals. For instance, in the process of implementing "smart transportation" projects, government customers need information technology knowledge, public service knowledge, and urban planning knowledge. Therefore, mining and managing cross-domain knowledge to make it readily accessible and applicable to customer-specific business goals pose substantial challenges to Mars. To address these challenges, Mars employs its data analytics capability, which involves extracting actionable and portable knowledge from raw government data (Saggi and Jain, 2018). This capability comprises two sub-themes. Table 5 presents the evidence of data analytics capability.

First, the data mining theme refers to the ability to extract actionable knowledge from massive amounts of data. Mars systematically categorizes raw government data based on business goals and application scenarios using the "Domain-wide Knowledge Service Platform" as well as digital technologies such as machine learning, artificial neural network, and natural language processing. This approach enhances the ability of enterprises to use the extracted knowledge to solve practical problems by comprehensively identifying entities, attributes, relationships, and important events relevant to specific industries. Moreover, Mars employs entity disambiguation technology to improve the efficiency of the mining of tacit knowledge, thus facilitating large-scale knowledge extraction. To date, Mars has extracted 3000 knowledge objects across approximately 60 application scenarios, including land management, forestry, emergency response, and taxation; thereby, Mars has built a comprehensive knowledge base covering a wide range of

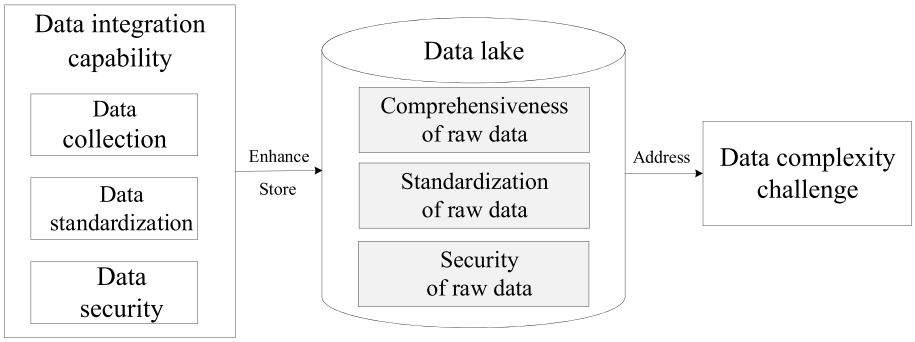

Fig. 2. Content of data integration capability.

Table 5
Representative quotations for each theme of data analytics capability.

Digital platform capabilities	Themes	Representative quotations
Data analytics capability	Data mining	● In undertaking the "Smart Court" project, Mars has generated 500 case knowledge maps and 150 smart service points for government customers based on the digital platform. This can provide information retrieval, error correction, and other functions for the decision-making process of judges. (D1) ● Mars has accumulated comprehensive knowledge that covers 90% of application areas, offering government departments an "encyclopedic" type of intelligent support. (D3) ● The "Domain-wide Knowledge Service Platform" enables Mars to help customers in different domains to realize knowledge deposition, knowledge sharing, knowledge searching, and knowledge collaboration. (D1)
	Knowledge modularization	● Knowledge modularity improves the reusability and extensibility of knowledge and thus provides better support for various application scenarios. (D1) ● Mars continuously adds or improves knowledge modules based on new application requirements from customers, thus enhancing the efficiency and effectiveness of knowledge across various application scenarios. (D1) ● Our product library currently houses a variety of personalized knowledge modules, which is our core competence. (D1)

government services.

Second, the knowledge modularization theme refers to the ability to integrate and encapsulate multiple pieces of knowledge into independent modules. By leveraging the "Domain-wide Knowledge Service Platform", Mars encapsulates the extracted knowledge into various modules based on modularization, which systematically summarizes common customer demands across multiple application scenarios. A knowledge module is a modular knowledge structure that is formed by integrating knowledge related to a specific business function and can be considered a distinct functional unit. For instance, the decision-making module comprises information, experiences, and patterns relevant for decision-making. These knowledge modules are independent, yet interconnected, through common interfaces and protocols, thus enabling them to be invoked individually or in combination across different application scenarios. In essence, these knowledge modules exhibit loose coupling, which enhances the portability of knowledge (Eloranta et al., 2021; Günther et al., 2017). Currently, Mars has developed more than 30 knowledge modules, such as "regulatory module", "business module", "forecasting module", and "decision-making module". These modules have been swiftly deployed across more than 50 application scenarios. The CMO recalled,

> "*These knowledge modules are like 'building blocks'. Regardless of the business scenarios our customers face, we can flexibly extract knowledge components according to their unique needs and quickly put them together into new solutions*".

In summary, to address the knowledge management challenge, Mars leverages its data analytics capability to mine raw government data and modularize knowledge. This process enables the extraction of actionable and portable knowledge from raw data and facilitates the construction of a comprehensive knowledge base. The components of digital analytics capability are illustrated in Fig. 3. Therefore, the following proposition is proposed.

P2. In the context of digital servitization, data analytics capability, including data mining and knowledge modularization, enables digital enterprises to extract actionable and portable knowledge from raw data, thereby addressing the knowledge management challenge.

4.1.3. Data productization capability

Over the course of implementing digital servitization, visualizing data through specific service offerings is crucial to helping government customers achieve their business goals in targeted application scenarios (Faroukhi et al., 2020). Service offerings are predominantly presented through visualization systems, applications, and mobile Apps (Kohtamäki et al., 2020; Raddats et al., 2019). Mars realized that government customers seek both common and customized functionalities in these service offerings. The common demand lies in the desire to perform multiple functions (such as early warning, command, and information dissemination) within a single service offering. In contrast, personalized demand emerges from customers in distinct application scenarios who desire tailored functionalities, such as virtual training. To meet the product functionality challenge, Mars utilizes its data productization capability. This capability involves developing service offerings by effectively configuring knowledge modules. The analysis identified the two sub-themes of knowledge fusion and knowledge optimization. Table 6 presents the evidence of data productization capability.

First, the knowledge fusion theme involves the ability to organically combine multiple knowledge modules. This ability enables Mars to build visual and comprehensive service offerings tailored to the common demands of government customers (Wei et al., 2022; Gremyr et al., 2019). For instance, Mars utilized the "low-code development platform" to

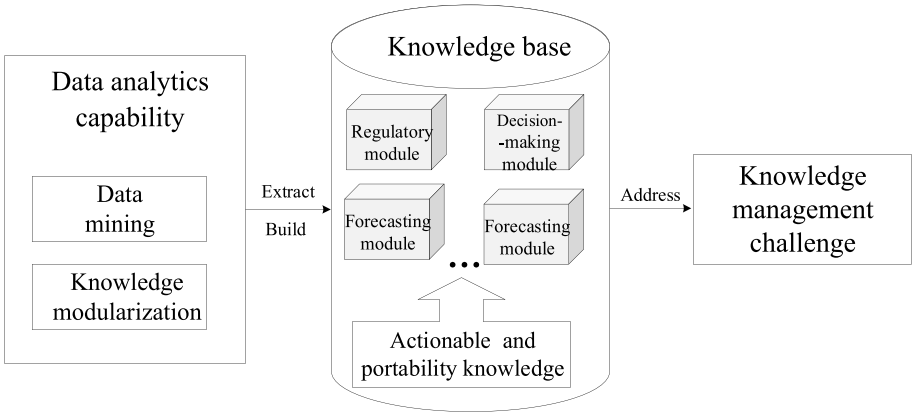

Fig. 3. Content of data analytics capability.

Table 6
Representative quotes for each theme of data productization capability.

Digital platform capabilities	Themes	Representative quotations
Data productization capability	Knowledge fusion	● Different knowledge modules can be combined and collaborate more easily on the "Low-Code Development Platform", thus facilitating rapid development of new service offerings. (D1) ● Most of Mars' service offerings result from organic combinations of different knowledge modules, with digital platforms enhancing the efficiency of the development of service offerings. (D2) ● Our statistics indicate that the current knowledge modules in the product library can satisfy 90% of our customers' demands. (D1)
	Knowledge optimization	● Typically, Mars is not entirely developing new service offerings. Instead, we focus on recombining and optimizing different knowledge modules using digital platforms. (D1) ● When new customers present personalized requirements, Mars mainly relies on digital platforms to make moderate adjustments to existing knowledge modules in response. (D1) ● In response to new customer requirements, we only need to add a few personalized functional knowledge modules to the original product, such as intelligent Q&A modules, to quickly develop customized products. (D1)

seamlessly integrate the "decision module", "process module", and "profile module" on the design interface of the platform. This integration led to the launch of the "One-stop Online Administrative Service" for the public service department of Province S. This service offers an integrated application system capable of quickly completing tasks such as the simultaneous reviewing, approving, tracking, and providing feedback on various matters online. Similarly, Mars combined the "early warning module", "monitoring module", and various other knowledge modules to introduce the "Integrated Emergency Management System" for the emergency management department of Province C. This system offers functions such as risk warning, dispatch command, and flood season monitoring for natural disasters like geological hazards and floods, presented on a large visualization screen.

Second, the knowledge optimization theme refers to the ability to adapt and refine existing combinations of knowledge modules. Knowledge optimization allows the better tailoring of service offerings to the individual business demands of government customers under specific application scenarios (Wei et al., 2019). For instance, Mars utilized the "low-code development platform" to optimize the combination of "public module" and "service module", and subsequently added a "city planning module", a "vehicle networking module", and others. On this basis, Mars introduced a new "One-stop Online Administrative Service" for City H, referred to as "Smart City H". Over recent years, by adjusting and optimizing the structure and method of combining knowledge modules, Mars has developed more than 30 service offerings to meet the individual demands of local customers in more than 150 cities. These offerings include "Smart Audit and Smart Office", "Yu Quick Office", and "Non-discriminatory Acceptance Hall".

In summary, to address the challenge of product functionality, Mars has leveraged its digital productization capability to develop comprehensive and customized service offerings by integrating and optimizing knowledge modules. This approach assists government customers in specific application scenarios to achieve their business goals. The details of the digital productization capability are illustrated in Fig. 4. Consequently, the following proposition is proposed.

P3. In the context of digital servitization, data productization capability, including knowledge fusion and knowledge optimization, enables digital enterprises to develop comprehensive and customized service offerings, thereby addressing the product functionality challenge.

4.2. Data value in digital servitization

Based on an analysis of case data, this study identified that the successful digital servitization implementation of Mars delivers two types of data value to government customers: function-oriented value and novelty-oriented value. As highlighted by Struwe and Slepniov (2023), "value" is an experiential concept; the data value of digital enterprises is determined by customers when applying the provided service offerings to achieve business goals.

4.2.1. Function-oriented value

Function-oriented value refers to service offerings that assist customers in achieving specific business goals with enhanced quality under specific application scenarios. For government customers, improved quality emphasizes increased efficiency and precision in achieving business goals, such as emergency management and public services. For instance, the "Integrated Emergency Management System", which was developed by Mars, enables emergency management departments to collect and analyze massive data comprehensively and dynamically and in real-time. This is achieved by connecting a wide range of equipment

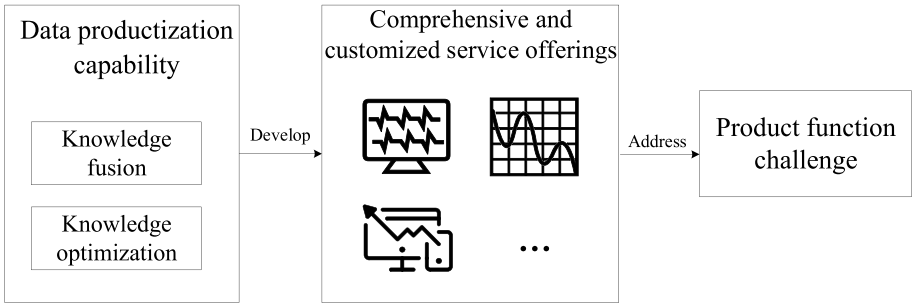

Fig. 4. Content of data productization capability.

or systems, including communication satellites, drones, detectors, and electronic boundary pillars. Such a system allows decision makers to assess the development trends and potential consequences of disasters (like earthquakes and floods) efficiently and accurately on a visualization screen, thus facilitating timely warning messages. Similarly, the "One-stop Online Administrative Service" enables different government services to collaborate through a single App. This enables the public to simultaneously handle a broad spectrum of government affairs online, such as e-documents, business licenses, and tax payments, thereby enhancing the efficiency and quality of service for government customers. Table 7 provides evidence of function-oriented value. Consequently, the following proposition is proposed.

P4. Successful implementation of digital servitization can deliver function-oriented value to customers.

4.2.2. *Novelty-oriented value*

Novelty-oriented value refers to assisting customers to achieve their unique business goals across various application scenarios by developing tailored service offerings. For instance, Mars has constructed a new tax service model for City B, which was named the "Meta-Universe Virtual Office Hall", leveraging digital platform capabilities and technologies such as AI, cloud computing, and virtual reality. This model closely replicates the physical tax environment online, thus reducing reliance on physical space and personnel. As a result, the model significantly boosts the efficiency and flexibility of government tax officials. Additionally, Mars established the China's first intelligent waste treatment system during the "Precise Waste Management" project in S City. This system addresses existing weaknesses in waste management by assisting multiple municipal and county-level departments in establishing an efficient management coordination mechanism, thereby achieving precise urban waste governance. Table 7 presents evidence supporting the novelty-oriented value. Consequently, the following proposition is proposed.

P5. Successful implementation of digital servitization can deliver novelty-oriented value to customers.

Table 7
Representative quotations of data value.

Data value	Representative quotations
Function-oriented value	● The product developed for City A not only reduced the timeframe for various business approvals for the Transportation Bureau by 90%, but also reduced the cost of repeated submissions and tedious queuing for the public offline. According to statistics, Mars saves enterprises and citizens more than 10 million yuan in office costs annually. (D1) ● Mars has developed service products like "Smart Approval", which enhance the approval process for government departments, thus offering enterprises and the public a novel experience of approval services with features such as "material-free submission" and "face-scanning approval processing", which achieved an increase in approval efficiency by over 60%. (D1) ● The City Safety and Emergency Management Big Data Platform currently holds 4.92 billion data entries, enabling 24-h online monitoring and accurate early warning for 998 high-risk enterprises in City C. (D1)
Novelty-oriented value	● Our successful cases and applications span various sectors. We have delivered quality services to government customers across 40 application scenarios, including transport, energy, culture, tourism, and healthcare. (D1) ● We launched the Smart Tax Office in City J, marking a significant upgrade in digital tax administration nationwide. Through the introduction of AI digital humans, welcome robots, and other intelligent devices, we offer taxpayers a smarter and more convenient tax experience. (D1) ● Mars has undertaken innovative initiatives in wildlife conservation. The Wildlife Monitoring and Early Warning Platform achieves second-level identification of wild animals and timely tracking of their positions and trends by leveraging satellite positioning technology. (D1)

4.3. *Research analysis*

A conceptual framework is proposed with which to analyze digital servitization in digital enterprises, illustrated through an in-depth case study of a digital enterprise in China, as depicted in Fig. 5. The framework clarifies two pivotal aspects: the digital platform capabilities required by digital enterprises to unlock data value in the context of digital servitization; and how these capabilities unlock data value, thus facilitating the successful implementation of digital servitization in digital enterprises. This paper draws the following conclusions from the conceptual framework.

4.3.1. *Role and relationship of capabilities*

This study found that in the context of digital servitization, the unlocking of data value hinges substantially on three digital platform capabilities: data integration, data analytics, and data productization. Distinct from traditional digital capabilities, these specific capabilities leverage the unique attributes of digital platforms to act as "reservoirs", "catalysts", and "pipelines" (in sequence). This process ultimately transforms massive, disparate, and raw data into valuable service offerings. As a result, digital enterprises can effectively unlock data value for their customers, thus facilitating the successful implementation of digital servitization (as illustrated in Fig. 5).

First, data integration capability serves as a "reservoir" for unlocking data value. Unlike traditional digital capabilities that focus on data acquisition (Opresnik and Taisch, 2015; Faroukhi et al., 2020; Saggi and Jain, 2018), the data integration capability harnesses the connectivity of digital platforms (Liu et al., 2023). This enables the comprehensive collection of raw data by linking a broad spectrum of physical devices and systems across various application scenarios. Additionally, this capability also leverages the compatibility of the digital platform (Liu et al., 2023) to incorporate technologies such as AI and cloud computing, thus enhancing the standardization and security of heterogeneous data. Consequently, data integration capability empowers

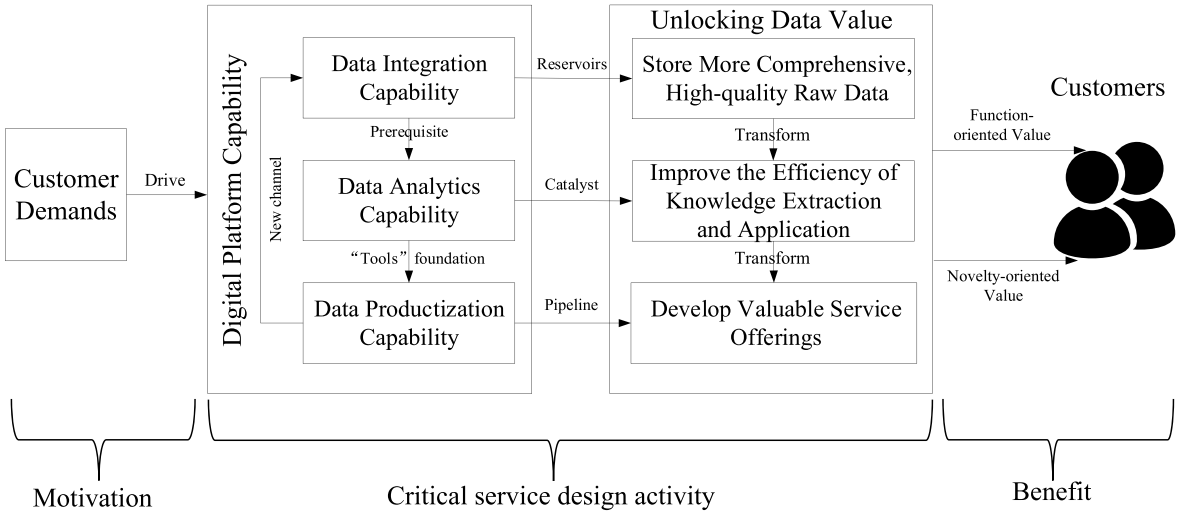

Fig. 5. Conceptual framework.

digital enterprises to store more comprehensive, high-quality, and raw data, thus increasing the potential for extensive knowledge extraction (Günther et al., 2017).

Second, data analytics capability functions as a "catalyst" in unlocking data value. In contrast to traditional digital capabilities related to data analytics (Li et al., 2022; Ferraris et al., 2019), data analytics capability relies on the compatibility of digital platforms (Liu et al., 2023). The data analytics capability integrates digital technologies such as machine learning and artificial neural networks, thus reducing the complexity associated with extracting rich and actionable insights from massive data (Saggi and Jain, 2018; Davenport and Ronanki, 2018). More importantly, this capability leverages the modularity of digital platforms (Cenamor et al., 2019; Eloranta et al., 2021), emphasizing the enhancements of knowledge portability and application efficiency through general-purpose modules. This enhancement ultimately equips customers with the tools to address practical challenges across diverse application scenarios. As a result, data analytics capability enables digital enterprises to improve the efficiency of knowledge extraction and application, thereby accelerating the unlocking of data value.

Third, data productization capability plays a "pipeline" role in unlocking data value. This capability primarily depends on the generation and modularity of digital platforms (Yoo et al., 2012; Eloranta et al., 2021). It enables the development of valuable service offerings that can help different customers to achieve their business goals by organically fusing and optimizing knowledge modules. In essence, digital productization capability allows digital enterprises to present and deliver data value to customers in a more understandable and customized form, thus ultimately unlocking data value. For instance, government customers can obtain function-oriented and novelty-oriented value by using visualization application systems or application software developed by Mars.

Furthermore, this study disclosed that the three capabilities are interconnected and operate in a particular iterative order. Specifically, data integration capability prepares raw data for knowledge mining, thus serving as a prerequisite for data analytics capability. Portable knowledge modules extracted by data analytics capabilities offer customers a diverse range of "functional parts" for developing customized service offerings. Therefore, data analytics capability establishes the foundational "tools" for data productization capability. Lastly, digital productization capability continually allows digital enterprises to capture the data required by customers through service offerings, thereby serving as a new source to further enhance data integration capability. Consequently, this study perceives digital platform capability as a system that is composed of interdependent and interconnected sub-capabilities. Systems thinking emphasizes the understanding of the "whole" and configurations of relationships (Ghosh et al., 2022). This approach aids in comprehending digital platform capability as a dedicated dynamic capability to unlock data value by integrating and reconfiguring data resources in the digital servitization context.

4.3.2. *Differences between digital enterprises and traditional manufacturers*

As noted by Kowalkowski et al. (2017), digital servitization is not confined to traditional manufacturers or other product firms. This paper focuses on a case study of digital servitization in a digital enterprise. The results show that digital servitization in digital enterprises refers to the process in which enterprises, driven by customer demands, leverage digital platform capabilities to unlock and provide data value for their customers, as shown in Fig. 5. Moreover, the differences in digital servitization between digital enterprises and traditional manufacturers were analyzed along the three dimensions of motivation, critical service design activity, and benefit, as illustrated in Table 8.

(i) Motivation. The motivations of traditional manufacturers to implement digital servitization have generally been driven by their desires for improved financial performance and for gaining the competitive advantage through their products and services (Raddats et al., 2019; Favoretto et al., 2021). In other words, the motivations of traditional manufacturers can typically be categorized into one of two types: competitive and economic (Raddats et al., 2019). However, this study finds that the motivations of digital enterprises to achieve digital servitization are

Table 8
Comparison of digital servitization between traditional manufacturers and digital enterprises.

Categories	Digital servitization in traditional manufacturers	Digital servitization in digital enterprises
Motivation	Competitive and economic motivations	Customer demand motivations
Critical service design activity	Reshaping internal operational processes	Leveraging digital platform capabilities to unlock data value
Benefit	Internal value in service, strategy, marketing, and other aspects	Providing data value to different customers
Business logic	Transformation logic from product-centric to service-centric	Service-dominant logic

more oriented towards customer demand. For instance, the Mars case shows that government customers' "integrated operations" demands in the process of building a digital government drive the enterprise to implement digital servitization.

(ii) Critical service design activity. The critical service design activities of traditional manufacturers have focused on reshaping internal operational processes, which include product-service development, sales, and service delivery processes (Shen et al., 2023; Favoretto et al., 2022). Existing research has emphasized the need for traditional manufacturers to utilize digital technologies in redesigning operational processes to achieve digital transformation more effectively (Shen et al., 2023; Raddats et al., 2019). In contrast, this study posits that critical service design activities in digital enterprises focus on leveraging digital platform capabilities to unlock data value for customers. The Mars case confirms that digital servitization is a complex process (Weerabahu et al., 2022), often encountering various challenges associated with unlocking data value, such as data complexity, knowledge management, and product function challenges. This complexity necessitates that digital enterprises address these challenges by harnessing a range of digital platform capabilities. Such an approach helps them to sequentially deploy the different roles of these capabilities, thereby effectively unlocking data value for customers.

(iii) Benefits. For traditional manufacturers, the benefits of digital servitization primarily revolve around enhancing their competitiveness by offering high-performance products, advanced services, and reducing energy consumption (Paschou et al., 2020; Favoretto et al., 2021; Wang et al., 2023a,b). In contrast, this study shows that digital servitization in digital enterprises is mainly used to create and deliver value to customers. This value manifests through assisting customers in solving business challenges and improving their overall experience (Paschou et al., 2020). Specifically, through the development of tailored service offerings, digital servitization enables digital enterprises to offer data value to diverse customers, encompassing both function-oriented and novelty-oriented value. In this sense, digital servitization also enhances the potential for digital enterprises to achieve a satisfactory return on investment in servitization across a broader customer base (Golgeci et al., 2022).

In summary, the digital servitization journey of traditional manufacturers follows the transformational logic, transitioning from a product-centric to a service-centric approach. In contrast, in digital enterprises, digital servitization adopts a service-dominant logic, driven by the aspiration to unlock and deliver data value to customers more effectively. This aligns more closely with the traditional concept of servitization, which centers on the creation and delivery of value to customers (Green et al., 2017; Raddats et al., 2019).

5. Theoretical and managerial implications

5.1. Theoretical implications

This study offers three primary theoretical contributions: First, it broadens the scope of research on digital servitization by developing a conceptual framework for digital servitization in digital enterprises. Despite the growing interest in digital servitization among digital enterprises (Struwe and Slepniov, 2023; Yan et al., 2022), mainstream research has predominantly focused on traditional manufacturers (Paschou et al., 2020; Tronvoll et al., 2020; Kohtamäki et al., 2019), resulting in a substantial gap in the understanding of this phenomenon. To address this gap, this study proposes a new concept of digital servitization from the perspective of digital enterprises. In this context, the findings resonate with the assertion of Kowalkowski et al. (2017), namely that "digital servitization is not confined to traditional manufacturers or other product firms." Additionally, this research delineates the differences in digital servitization between digital enterprises and traditional manufacturers across the three dimensions of motivation, key service design activity, and benefit. Overall, while traditional manufacturing enterprises tend to follow a transformational logic, the approach of digital enterprises to digital servitization aligns more closely with a service-dominant logic, as it emphasizes the provision of data value to customers. This perspective is consistent with the original research on traditional servitization, which focuses on creating and delivering value to customers (Green et al., 2017; Raddats et al., 2019). Therefore, the digital enterprise perspective can be considered as a sub-stream that contributes to the ongoing discussion about the boundaries of digital servitization (Khanra et al., 2021).

Second, this study enriches the literature on digital platform capabilities. Although the existing digital servitization literature suggests that digital platform capabilities hold significant potential for unlocking data value (Jovanovic et al., 2022; Struwe and Slepniov, 2023; Momeni et al., 2023; Giustiziero et al., 2023), the understanding of the specific components of digital platform capabilities is limited and how these capabilities facilitate the successful implementation of digital servitization also remains largely unknown. This research identifies three key digital platform capabilities in the context of digital servitization: data integration capability, data analytics capability, and data productization capability. In contrast to previous studies (Chen et al., 2023; Faroukhi et al., 2020; Li et al., 2022; Ferraris et al., 2019), this research not only highlights the unique roles these capabilities play in unlocking data value, but also emphasizes their interdependence. This perspective allows to perceive these capabilities as an integrated system, collectively constituting a dedicated dynamic capability that both integrates and reconfigures data resources to unlock data value. Addressing a demand in the literature (Annarelli et al., 2021), the insights obtained enable a more nuanced empirical understanding of both the structure and content of digital platform capabilities. It also helps to reveal the manifestations of dynamic capabilities in digital servitization context.

More importantly, this study shows that three digital platform capabilities collectively unlock data value by sequentially serving as "reservoirs", "catalysts", and "pipelines". This sequential role-playing facilitates digital enterprises in successfully implementing digital servitization. This finding resonates with the call of Favoretto et al. (2022) for studies to examine the contributing role of digital platform capabilities in digital servitization, thus further strengthening the link between digital technologies and servitization (Paschou et al., 2020; Shen et al., 2023).

Third, this study contributes to the literature on data value. While both academic and practitioner-oriented streams of the literature have increasingly focused on data value in digital servitization in recent years (Opresnik and Taisch, 2015; Eggert et al., 2022; Wang et al., 2023a,b; Sestino et al., 2020), several studies have highlighted the challenges associated with unlocking data value (Saggi and Jain, 2018; Günther et al., 2017). Despite these challenges, there a lack of practical guidance on leveraging digital technologies to unlock data value remains. This research confirms that leveraging digital platform capabilities is key to unlocking data value in digital servitization. Specifically, these capabilities can play three distinct roles in a specific iterative order to address various challenges, thereby effectively unlocking data value.

5.2. Managerial implications

This study provides valuable insights for digital enterprises such as SHEIN, SAS Institute, and Yonyou related to the building and refining of their digital platform capabilities to implement data servitization, which ultimately unlocks data value and enhances their competitive advantage.

First, when implementing digital servitization, digital enterprises should adopt a service-dominant logic, and focus on understanding

customer demands to deliver targeted data value. This logic and focus involve deep interactions with customers through interviews, questionnaires, and market research to gather customer information timely and systematically. Subsequently, enterprises should utilize Big Data technology to generate customer demand analysis reports, encompassing customer profiles, and key demand information. This enables digital enterprises to offer more precise customized service offerings and unique data value. Additionally, this article highlights the importance for digital enterprises to actively use digital technologies such as data transmission encryption, access control, and blockchain to safeguard both the security and privacy of data (particularly public data).

Second, a defined set of digital platform capabilities is essential to assist digital enterprises in unlocking data value. This study highlights that unlocking data value is a challenging multi-step process. Thus, this list serves as a roadmap for digital enterprises to strategically develop and utilize digital platform capabilities to enhance their effectiveness in unlocking data value. While building these capabilities quickly poses challenges, which require substantial investment in resources such as technical personnel and funding, digital enterprises can foster these capabilities by hiring and training digital talents such as data scientists and software engineers. Moreover, collaboration with partners, including software and cloud service providers, can expedite the construction of digital platforms.

Third, this study underscores the importance of creating portable knowledge modules for digital enterprises to provide tailored service options for customers. Therefore, digital enterprises should harness digital platform capabilities to transform fragmented knowledge into numerous loosely coupled knowledge modules. This approach allows digital enterprises to adapt to changes and personalized needs by integrating and optimizing knowledge modules, thereby expanding their revenue through a broader array of services.

Fourth, the government should provide strong support for digital enterprises to successfully implement digital servitization in terms of data regulations, financial subsidies, and digital infrastructure. On the one hand, the government should improve data security and privacy protection regulations to ensure compliance of digital enterprises when unlocking data value. On the other hand, the government should provide tax relief policies for digital enterprises implementing digital servitization and set up special funds to support enterprises' investment in the construction of digital platforms. In addition, the government can also provide free digital diagnostic and consulting services to help digital enterprises to develop more appropriate digital servitization solutions.

5.3. Limitations and future research

Despite its novelty and value, this paper has limitations that point to avenues for future research. First, like many qualitative studies, the generalizability of the findings requires further quantitative validation. Future studies could expand the obtained insights by exploring digital servitization in diverse settings and by employing quantitative methods to confirm findings. Second, the successful implementation of digital servitization in digital enterprises is influenced by environmental dynamics and relationships within the ecosystem (Favoretto et al., 2022). This study did not delve into these aspects, which could be explored in future research. Additionally, the focus of this study on digital enterprises engaged in the e-government sector may not capture the differences in digital servitization processes across various business fields and service targets. Future research could conduct comparative case analyses involving different types of digital enterprises (e.g., Google, Amazon, Facebook, Alibaba, or Airbnb) to broaden theoretical boundaries. Third, to mitigate the limitations associated with snowball sampling, future studies should diversify and increase the number of interviewees to enhance the reliability of the research findings.

6. Conclusion

To gain a more insightful understanding of the concept of digital servitization in digital enterprises, this research explores the components of digital platform capabilities as well as their roles in unlocking data value. To achieve these goals, an in-depth case study of a digital enterprise in China was conducted. The findings disclose a set of three digital platform capabilities, namely data integration capability, data analytics capability, and data productization capability. Importantly, these capabilities, which are grounded in the characteristics of digital platforms, sequentially function as "reservoirs", "catalysts", and "pipelines" that unlock data value, thus enabling the successful implementation of digital servitization. Furthermore, contrary to the established literature that excessively focuses on traditional manufacturers, this study introduces a new concept of digital servitization from the digital enterprise perspective. This perspective refers to the process in which, propelled by the demands of their customers, enterprises leverage digital platform capabilities to unlock and deliver data value to customers.

CRediT authorship contribution statement

Yibo Jia: Writing – original draft, Supervision, Methodology, Conceptualization. **Li Cui:** Writing – original draft, Conceptualization. **Jingqin Su:** Writing – original draft, Validation, Conceptualization. **Lin Wu:** Writing – original draft, Methodology, Conceptualization. **Shahriar Akter:** Writing – review & editing, Supervision, Conceptualization. **Ajay Kumar:** Writing – original draft, Methodology, Conceptualization.

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Data availability

Data will be made available on request.

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