From ambidextrous innovation to digital servitization: The moderating role of digital empowerment in Vietnamese Small and Medium-sized manufacturing Enterprises (SMEs)

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ABSTRACT

This study investigates how innovation ambidexterity and digital empowerment jointly enable digital servitization and performance outcomes in manufacturing SMEs in an emerging economy context. Drawing on dynamic capabilities theory and the servitization/digitalization literature, we conceptualize exploratory and exploitative innovation as microfoundations of digital servitization and examine digital empowerment as an internal enabling condition. We propose that digital servitization, in turn, enhances both operational effectiveness and customer participation in value co-creation. Using survey data from 205 owners and CEOs of Vietnamese manufacturing SMEs and 5-point Likert scales, we test the research model with Partial Least Squares Structural Equation Modelling (PLS-SEM). The results show that both exploration and exploitation innovation positively influence digital servitization, with a stronger effect for exploration innovation. Digital empowerment significantly strengthens the relationship between exploitative innovation and digital servitization, but does not significantly moderate the exploratory innovation-digital servitization link. Digital servitization exerts significant positive effects on operational effectiveness and on customer participation in value co-creation, underscoring its significant role in translating innovation capabilities into both efficiency and relational gains. The study advances understanding of the microfoundations of digital servitization in manufacturing SMEs, nuances the role of digital empowerment as a contingent rather than universal amplifier of innovation ambidexterity. It provides actionable implications for SME leaders seeking to leverage digital tools, skills, and autonomy to turn innovation efforts into digitally enabled service offerings and improved performance.

1. Introduction

Digitalization is redefining the industry at an unprecedented speed. Digitalization - defined as the embedding and leveraging of digital technologies in products, processes, and business models to create novel value for customers (Abou-Foul et al., 2020; Kieu et al., 2025) - has become a strategic imperative for manufacturers. As digital technologies diffuse,

manufacturing firms increasingly shift from primarily product-based logics toward digitally enabled service-oriented business models to strengthen customer centricity and develop distinctive value propositions (Kohtamäki et al., 2019). Prior evidence suggests that digitalization contributes positively to firms' innovation outcomes, operational effectiveness, and competitiveness (Favoretto et al., 2022; Yang & Yang, 2021). A recent systematic review synthesizing three decades of research highlights digital servitization as a core strategic pathway for manufacturers operating in the digital economy (Minaya et al., 2024). Evidence from China further indicates that firms may follow different digital transformation paths, yet these paths typically require sufficient digital maturity and operational flexibility (Meng et al., 2025). This strategic shift is particularly salient for emerging economies such as Vietnam, where digital servitization can help manufacturers upgrade positions in global value chains and differentiate from low-cost challengers (Almodóvar & Nguyen, 2022).

Importantly, digital servitization is not merely the outcome of investing in digital technologies. Rather, it reflects a firm's ability to reconfigure resources, processes, and innovation activities to deliver digitally enabled service offerings. From a dynamic capabilities perspective, innovation ambidexterity, i.e., the ability to pursue exploratory and exploitative innovation concurrently, can be considered a key capability underpinning such transformation (Ardito et al., 2018; Coreynen et al., 2017; Coreynen et al., 2020; O'Reilly & Tushman, 2008). Exploratory innovation supports experimentation with novel technologies and new digitally enabled value propositions. In contrast, exploitative innovation enables disciplined refinement, scaling, and efficient deployment of digital solutions in existing products and routines. Empirical research increasingly shows that ambidexterity plays a foundational role in developing and scaling digital business models (Peña et al., 2019; Qi et al., 2020). In Vietnam, recent evidence also suggests that open innovation and dynamic capabilities can foster ambidexterity and improve firm performance (Huynh et al., 2025), consistent with broader arguments that balancing search and refinement is critical for innovation success in emerging Asian markets (Nakandala et al., 2025).

However, the link between innovation ambidexterity and digital servitization may not be uniform; it can depend on contextual enablers. One such enabler is Digital Empowerment (DE), defined as the extent to which firms equip employees with digital resources, capabilities, and autonomy to innovate (Magnusson et al., 2020). Organizational culture and technological infrastructure jointly shape employees' ability to engage in digital experimentation and problem-solving. Recent studies emphasize that digital empowerment can increase adaptive capacity, innovation vitality, and cross-boundary process integration in manufacturing ecosystems (Zhu et al., 2024). Evidence from China suggests that digital empowerment is associated with higher productivity and managerial efficacy, especially in R&D-intensive contexts (Qiu et al., 2024). It may also strengthen autonomy and resilience during crises (Li et al., 2022). Collectively, these insights imply that firms with stronger digital empowerment may be better able to translate both exploration- and exploitation-oriented innovation into digital service outcomes. Nevertheless, empirical research that explicitly examines digital empowerment as a moderator within the innovation ambidexterity-digital servitization relationship remains limited, particularly in developing-economy SME settings.

Beyond antecedents, digital servitization is expected to reshape both internal operations and customer-firm interaction, two key drivers of competitive performance. On the operational side, digital technologies embedded in service processes can enhance flexibility, coordination, and efficiency by enabling real-time data access, automation, and platform-based integration

(Yang & Yang, 2021). On the relational side, digital servitization can foster Customer Participation in Value Co-creation (CPVC) by enabling interaction through connected products, online platforms, and collaborative interfaces (Yang & Yi, 2021; Zhao et al., 2019). Such participation can improve service customization, feedback quality, and the relevance of innovation. In Vietnam, co-creation has also been linked to better system-level functioning in coordination and responsiveness (Huynh et al., 2023). Yet how innovation, ambidexterity, and digital empowerment jointly shape these operational and relational outcomes through digital servitization in Vietnamese manufacturing SMEs remains insufficiently understood.

Accordingly, this study aims to explain how innovation ambidexterity translates into digital servitization, how digital empowerment conditions this process, and how digital servitization affects operational and relational outcomes in Vietnamese manufacturing SMEs. Specifically, we address the following research questions:

RQ1: Do exploratory innovation and exploitative innovation differentially influence digital servitization in manufacturing SMEs?

RQ2: Does digital empowerment moderate the effects of exploration and exploitation innovation on digital servitization?

RQ3: Does digital servitization enhance operational effectiveness and customer participation in value co-creation?

This paper contributes in three ways. First, building on the dynamic capabilities view and the knowledge-based view under resource constraints, we distinguish exploratory and exploitative innovation and examine their differential effects on digital servitization in manufacturing SMEs. Second, we theorize and test digital empowerment as a contingent moderator that shapes when and for which type of innovation, the translation into digital servitization is stronger. Third, we link digital servitization to operational effectiveness and customer participation in value co-creation, thereby extending digital servitization research beyond financial or market outcomes and providing evidence from Vietnam's emerging economy.

2. Theoretical background and hypothesis development

2.1. Dynamic capabilities, innovation, ambidexterity, and digital servitization

Firms maintain performance in changing conditions by developing higher-order capabilities that enable them to sense opportunities and threats, seize them through investments, and reconfigure organisational resources (Teece, 2007). In manufacturing, digital servitization - the embedding of digital technologies into service offerings and service-supporting processes - can be considered as a dynamic capability (Abou-Foul et al., 2020; Zhang et al., 2016). Digital servitization is a fusion of products, services, and digital COM in which organizations can sense changes in customer requirements through data, seize them through new digitally enabled service solution components or bundles, and reconfigure internal processes and partner relationships to deliver them efficiently (Favoretto et al., 2022). Innovation ambidexterity provides important microfoundations for this capability (Božič & Dimovski, 2019). Exploratory innovation (EL) is the experimentation with new products, processes, and markets that contributes to sensing and reconfiguring the dimensions of dynamic capabilities. Exploitative innovation (EX), on the other hand, is directed at improving existing products and processes and aims to deliver fast-paced technological change, closely related to seizing opportunities and increasing the reliability and efficiency of production. For manufacturing SMEs in emerging economies, both EL and EX are likely to be pivotal for acquiring digital servitization

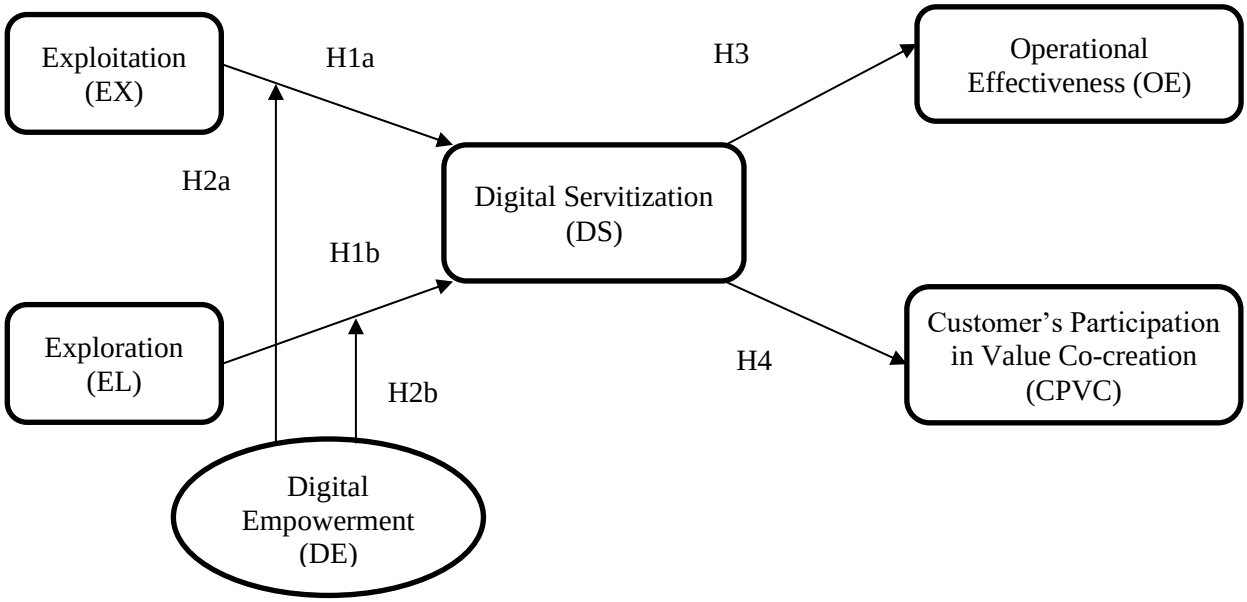
capabilities: exploratory initiatives can identify new digitally enabled value propositions, and exploitative initiatives can embed digital technologies into extant products and service routines. (Božič & Dimovski, 2019; Qi et al., 2020; Zhang et al., 2016). Accordingly, we expect both forms of innovation to be positively associated with digital servitization:

H1a: Exploitative innovation (EX) positively influences digital servitization

H1b: Exploratory innovation (EL) positively influences digital servitization

Figure 1

Research Model and Hypothesis



Note. The researcher's data analysis (Proposed research model (based on Božič and Dimovski (2019); Li et al. (2022); Kohtamäki et al. (2021); Vargo and Lusch (2008)))

Theoretically, digital servitization may serve as a capacity for both exploitation and exploration to drive innovation toward performance outcomes. Still, in this work, we focus on the direct links between ambidextrous innovation, digital servitization, and firm outcomes. There is a conceptual discussion of digital servitization that could mediate the impact, but this is not modelled as a formal mediation hypothesis, leaving space for future empirical exploration of this process.

2.2. Digital empowerment as a contingent boundary condition

Digital empowerment is the degree to which an organization provides its employees and leaders with knowledge, autonomy, resources, and motivation to use digital tools through their own efforts in their work (Li et al., 2022). It is manifested in employees' digital readiness, defined as "employee perceived readiness, willingness and ability to use digital tools" (Zhang et al., 2016, p.02) and their willingness to experiment with them, as well as managers' support for using digital offerings (Spreitzer, 1995; Zhang et al., 2016). Empowerment is positively linked to the generation of digital innovation ideas, cross-functional knowledge sharing, and support for change projects, indicating its beneficial role in the effective implementation of innovation and change projects by employees (Li et al., 2022). Through the lens of dynamic capabilities, digital empowerment implies a contextual facilitator that determines how firms operationalize innovation ambidexterity for digital servitization (Magnusson et al., 2020). In this case, employees can draw on data and digital platforms to capture incremental process

improvements, add digital features and services components to products or already developed solutions, and then codify those improvements into scalable digital service solutions (Li et al., 2022). Such a process is well-suited to exploitative innovation, which is characterized by the improvement and enhancement of the current line of services or practices (Zhu et al., 2024). Digital enablement may make exploratory innovation easier by enabling the use of experimental tools and prototypes. Yet, the actual transformation of radical, formless ideas into digital services depends more on top management's vision and strategic resource allocation than on daily operational empowerment (Qiu et al., 2024). From this perspective, digital empowerment is anticipated to increase the degree of conversion of experiments and exploitation innovations in digital servitization (Li et al., 2022). In a highly empowered organization, employees and middle managers can make greater use of digital tools to turn exploratory ideas into pilot digital services and to embed digital features and service components into existing products and processes. Yet the mechanisms outlined above indicate that digital empowerment is particularly compatible with exploitative innovation intended to repeat and codify existing practices. As a result, although digital empowerment is likely to reinforce both innovation and servitization relationships further, we propose that its moderating role will be stronger for exploitative innovation and weaker-and therefore potentially harder to observe empirically-for exploratory innovation, particularly among resource-constrained SMEs.

H2a: Digital Empowerment (DE) positively moderates the relationship between Exploration and Learning (EL) and Digital Servitization (DS), such that the relationship is stronger when digital empowerment is high

H2b: Digital Empowerment (DE) positively moderates the relationship between exploitation innovation (EX) and Digital Servitization (DS), such that the relationship is stronger when digital empowerment is high

2.3. Digital servitization and operational effectiveness

Operational effectiveness means a company can manage its operations and delivery processes efficiently and deliver high-quality products. This includes reduced lead times, increased agility, lower defect rates, and improved resource utilization. Previous research reveals that information technologies and service-based practices can support operational performance by enabling real-time visibility, coordination, and process standardization across various points along the value chain (Kohtamäki et al., 2021). Digital servitization embeds connected products, data analytics, and service processes into the nature of the business. Using embedded sensors and connectivity, manufacturers can continuously track how their equipment is used and maintained, proactively schedule service work orders, and optimize the deployment of service interventions. Data provided by digital services can help companies model and improve production planning, inventory management, and capacity allocation. In addition, the use of standard digital platforms for service delivery reduces manual work and errors, thereby enabling reliability and speed. These digital service capabilities enable SMEs to replace large-scale physical assets and complex legacy systems with a set of small apps, which have long been available with limited resources. Therefore, we hypothesize that higher digitization of servitizing companies would have a positive relationship with organizational effectiveness. Those suppliers who manage the implementation of digital technology well within their service offering feel more confident and move faster with their installed base or customer operating insights, enabling improved internal planning and control. Thus:

H3: Digital servitization positively influences operational effectiveness

2.4. Digital servitization and customer participation in value co-creation

Customer participation in value co-creation is understood as customers' involvement in the production, use, and improvement of a company's offering. In B2B manufacturing relationships, co-creation can, for instance, mean joint problem-solving, sharing operational data, collaborating on adapted or new processes, and generating content together (Kohtamäki et al., 2019; Vargo & Lusch, 2008). Studies show that sophisticated services and close cooperation lead to a higher degree of customer involvement and stronger, long-term relationships. Through digital servitization, manufacturers have several levers to engage customers more deeply in the co-creation of value. Interconnected products can create new interactive touchpoints -'portals' through which customers can track the status of their equipment, book services, or configure solutions. Performance-based insights into customer data enable a more transparent discussion of performance and results, which, in turn, makes customers more willing to provide detailed operational information and work with Amazon on opportunities for improvement. And finally, the concurrent development of digital service applications (dashboards, alerts, decision-support tools) means that customers must work hand in hand with producers to co-create solutions, thereby deepening mutual learning and trust. We thus predict a continued rise in the degree of customer involvement in value co-creation as manufacturers advance their digital servitization journey. Digital services not only offer (functional) benefits but also build a network in which customers are motivated to share knowledge, preferences, and data as part of the co-creation process.

H4: Digital servitization positively influences customer participation in value co-creation

3. Methodology

3.1. Sampling and data collection technique

A purposive sampling approach was used to target Vietnamese manufacturing Small and Medium-sized Enterprises (SMEs) across the North, Central, and South regions. The sampling frame was compiled from publicly available business directories and lists of manufacturing/industry associations in major industrial provinces. Firms were screened to ensure they operated in manufacturing, met the SME size criterion (self-reported number of employees: up to 500), and that the respondent held a senior role (owner, CEO, or general manager). Data collection lasted six months (October 2024 - March 2025). We distributed 230 structured questionnaires by post and collected responses via follow-up phone calls and email reminders. Two reminders were sent at six-week intervals. In total, 205 usable questionnaires were retained for analysis (effective response rate = 89.13%). We excluded questionnaires with substantial missing data (e.g., > 10% unanswered items), non-differentiated response patterns (straight-lining), and internally inconsistent answers.

3.2. Measurement scales of research constructs

All focal constructs were measured using established multi-item scales and rated on a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). To ensure linguistic and conceptual equivalence, the English questionnaire was translated into Vietnamese and back-translated by two independent bilingual experts, and discrepancies were resolved through discussion. The instrument was then pretested with a small group of SME managers to confirm clarity and face validity. To mitigate potential Common Method Variance (CMV), we assured respondents of anonymity and confidentiality, emphasized that there were no right or wrong answers, and separated the measurement of key predictors and outcomes into distinct questionnaire sections with neutral wording (Podsakoff et al., 2003).

Innovation ambidexterity is a firm's ability to conduct both exploratory and exploitative innovation concurrently. Exploratory innovation involves experimenting with new technologies, markets, and business models, whereas exploitative innovation focuses on improving existing products, processes, and capabilities (March, 1991; O'Reilly & Tushman, 2008). Ambidextrous companies' performance: It is argued that ambidextrous units are better performers because they can explore new opportunities while simultaneously exploiting existing strengths (Jansen et al., 2009; He & Wong, 2004). Consistent with previous studies in manufacturing and digitalization (Božič & Dimovski, 2019; Zhang et al., 2016), we measure innovation ambidexterity in this study as two distinct reflective constructs: exploratory innovation (EL) and exploitative innovation (EX). Items used to measure construction are multiple, which prompt respondents to indicate how much their firm engages in a particular activity, e.g., trying out radically new ideas (EL) or improving/updating existing product lines and processes (EX). In a further step, all items are defined as reflective indicators because they are considered manifestations of the underlying innovativeness orientation; therefore, changes in the latent construct are expected to have a reciprocal effect on all manifest variables in the same direction (Jarvis et al., 2003). In the structural model, EL and EX are included as independent variables reflecting the two dimensions of innovation ambidexterity. This methodological approach allows for the examination of their differential impact on digital servitization. It explores whether the effects of these concepts on digital servitization are dependent on the level of digital empowerment. We deliberately do not map innovation ambidexterity as either a formative or a single index (e.g., EL × EX or EL + EX) because we seek to theoretically explain the distinct yet integrated roles that exploratory and exploitative innovation play in enabling digital servitization among manufacturing SMEs.

Table 1

Summary of Constructs and Measurement Items

Variable	Dimension	Code	Reference
Innovation Ambidexterity (IA)	Exploitative (EX) Explorative (EL)	E1-E11	Božič and Dimovski (2019); Zhang et al. (2016); Coreyna et al. (2017); Coreyna et al. (2020)
Digital Servitization (DS)	Digitization (DI) Servitization (SER)	D1-D8	Lee et al. (2024); Coreyna et al. (2017); Coreyna et al. (2020)
Digital Empowerment (DE)	Resource Empowerment (RE) Structural Empowerment (SE) Platform Empowerment (PE) Ecological Empowerment (EE)	DE1-DE24	Li et al. (2022)
Operational Effectiveness (OE)		OE1-OE8	Li (2025); Gorla et al. (2010)
Customer's Participation in Value Co-creation (CPVC)	Co-production (COP)	CPVC1-CPVC14	Ranjan and Read (2016); Vargo and Lusch (2008); Yi and Gong (2013); Zengin and Yilmaz (2025)

Note. Authors' synthesis

Digital empowerment refers to the extent to which an organization enables employees to proactively use digital tools in their daily work through adequate digital resources, support, autonomy, and a climate that encourages initiative and experimentation. This concept is consistent with the empowerment perspective, emphasizing employees' perceived competence and self-determination at work, which is translated into digital contexts through access to digital infrastructure, skills, and enabling structures (Li et al., 2022; Spreitzer, 1995). In accordance with Lee et al. (2024), we conceptualize digital empowerment as a second-order reflective construct composed of four first-order dimensions: Resource Empowerment (RE), Structural Empowerment (SE), Platform Empowerment (PE), and Ecological Empowerment (EE). Measurement: this study adopted Allinson and Hayes's (1996) first-order dimensions, each measured reflectively using multiple items adapted from scales in the literature to align with the context of manufacturing SMEs. For our PLS-SEM model testing, we apply the repetitive-indicator approach, meaning that all items reflecting the four dimensions are regressed on their respective first-order constructs and, in addition, on the superordinate higher-order construct, digital empowerment. In this specification, digital empowerment is treated as the only latent variable that composes the common variance of RE, SE, PE, and EE, and is used in testing the structural model and the moderation test. The second-order reflective constructs, digital servitization and digital empowerment, are conceptualized in the structural model. The concept of digital servitization is captured by two first-order dimensions (digitization and service offering).

In contrast, the first four-order dimensions (RE, SE, PE, EE) characterize the notion of digital empowerment. Following, the repeated-indicator method is used to estimate the higher-order constructs; we then use the latent variable scores of exploratory innovation, exploitative innovation, digital empowerment, digital servitization, operational effectiveness, and customer participation in value co-creation for our structural analysis. To investigate the moderating effect of digital empowerment, we establish two interaction terms-EX×DE and EL×DE-using product-indicator method in PLS-SEM. These interaction types are formative but related to digital servitization as an endogenous variable. Therefore, digital empowerment is included in the structural model as a second-order construct that moderates the effects of exploratory and exploitative innovation on digital servitization (H2a-H2b).

Digital servitization represents a manufacturer's capability to transition from a product-centric logic toward digitally enabled service-based and outcome-oriented offerings, where value creation increasingly relies on combining digital technologies with advanced services. Prior research conceptualizes DS as a multi-dimensional capability that integrates product/process digitization (e.g., connectivity, sensing, and data processing) with servitization (i.e., the breadth and sophistication of service offerings and service business models) (Coreynen et al., 2017; Coreynen et al., 2020; Kohtamäki et al., 2021). In line with existing literature, which conceptualizes digital servitization as a multi-dimensional capability integrating product digitization and servitization (Coreynen et al., 2017; Coreynen et al., 2020; Kohtamäki et al., 2019), we propose modeling digital servitization as a second-order reflective construct of two lower first-order reflective dimensions (digitalization (DI) and servitization (SER)). The digitalization (DI) facet measures the extent to which companies incorporate connectivity, sensing, and data processing features into their products and processes. SER dimension covers the range and sophistication of servicisation practices, such as business models for those products (which have been digitised), preventative and predictive maintenance, performance-

based contracts, and advanced services moving from product sales towards selling usage and outcomes. Although the two dimensions are conceptually distinct, they emerge as closely related expressions of the same underlying capability: the development and delivery of value through digitally enabled product-service systems. As advised by guidelines on modeling conceptually interrelated multi-dimensional constructs (Becker et al., 2012; Lee et al., 2024), we treat DI and SER as first-order reflective factors loading onto the higher-level construct of digital servitization. Each dimension is measured reflectively using several items adapted from validated scales in the literature and recontextualized for manufacturing SMEs. In the PLS-SEM analysis, we use a repeated-indicator approach and load all DI and SER items onto both their associated first-order constructs and the second-order digital servitization construct. Then, the high-order factor score is used as a single latent variable for digital servitization in the structural model. For robustness, we modeled a crude composite digital servitization definition (D_raw) as the product of the mean scores for both dimensions of digitalization and servitization (D_raw = mean (DI) × mean (SER)) (Coreynen et al., 2017; Coreynen et al., 2020). This index is used only in secondary analyses to ensure the stability of findings when a single aggregate proxy measures digital servitization. It is not used as an independent construct in the main PLS-SEM structural model, where the aforementioned second-order reflective latent variable captures digital servitization.

Operational effectiveness captures the extent to which a firm achieves superior internal operational performance through efficient planning and control, sound decision-making, cross-functional coordination, and disciplined resource allocation. This view aligns with prior work that treats operational effectiveness as an internal capability reflected in process efficiency, managerial coordination, and the attainment of operational targets (Gorla et al., 2010; Li, 2025). OE, in this sense, is conceived as first-order reflective construct using eight items (OE1-OE8) construct explaining how internal processes of an organization enable good and wise decision making, coordination across functions, budgeting and capital allocation activities and the attainment of operational targets (comprising satisfaction of profitability of product or service line target to retain or improve market share, the planning efficiency). This definition is inspired by previous research on OPCs , which regards operational effectiveness as a key internal capability of organizational performance and the achievement of digital transformation goals. It locates OE as a productivity-oriented capability, consistent with strategic and innovation-related constructs in the general firm performance literature.

Customer participation in value co-creation refers to customers' active involvement in collaborative activities that contribute to value creation, consistent with the service-dominant logic, which views customers as operant resource integrators rather than passive recipients (Ranjan & Read, 2016; Vargo & Lusch, 2008). Building on Yi and Gong's (2013) scale and subsequent B2B adaptations (e.g., Zengin & Yilmaz, 2025), we adapt CPVC to the industrial SME context and model it as a second-order reflective construct consisting of three first-order reflective dimensions: co-production (COP), interaction (INT), and citizenship (CIT) (items CPVC1-CPVC14). The refined items focus on essential participatory activities such as providing technical information, coordinating joint actions, jointly solving problems, and responding to requests for product or process improvements, which are salient in long-term B2B relationships.

3.3. Higher-order construct modelling and moderation specification

For the reflective model, we assessed indicator reliability, internal consistency, convergent validity, discriminant validity (Fornell-Larcker criterion and HTMT), collinearity, explanatory power, and predictive relevance in line with established PLS-SEM reporting guidelines (Hair et al., 2019). The measurement and structural models were estimated using SmartPLS (version 4; SmartPLS GmbH, Boenningstedt, Germany) with bootstrapping (5,000 subsamples). In addition to the procedural remedies described above, we assessed potential common method variance statistically using the full collinearity VIF approach, where VIF values below 3.3 are commonly interpreted as suggesting that CMV is unlikely to bias the estimates (Kock, 2015). Digital Empowerment (DE), Digital Servitization (DS), and Customer Participation in Value Co-creation (CPVC) are modelled as reflective-reflective higher-order constructs. We use the two-stage approach recommended for such constructs in PLS-SEM (Becker et al., 2012; Lee et al., 2024). In the first stage, all first-order constructs (EL, EX, DI, SER, RE, SE, PE, EE, COP, INT, CIT, OE) are included in the model, and their measurement properties are assessed. Latent variable scores for the first-order dimensions of DE, DS, and CPVC are then saved and used as manifest indicators of the corresponding second-order constructs in a second-stage PLS-SEM estimation. This reduces model complexity while preserving the hierarchical nature of the constructions. For the structural analysis, we use the latent variable scores of exploratory innovations, exploitative innovation, digital empowerment, digital servitization, operational effectiveness, and customer participation in value co-creation obtained from the second-stage model. To investigate the moderating role of digital empowerment, we create two interaction terms, EX × DE and EL × DE, using the product-indicator method in PLS-SEM. These interaction constructs are linked to digital servitization as the endogenous variable, enabling us to test whether the effects of exploration and exploitation innovation on digital servitization depend on the level of digital empowerment.

4. Research results

The empirical research relies on survey data collected from 205 Vietnamese manufacturing SMEs (see Table 2), for which responses were obtained from senior business managers, who are usually the owner or CEO. This approach gives it theoretical and practical firm-level depth, allowing strategic orientation and operational reality to converge in the information that informs it. Fieldwork was conducted over 06 months from October 2024 and used a mailed, paper questionnaire. It is considered an effective approach for reaching SMEs in provinces. Also, this sample size is the minimum needed to run PLS-SEM (particularly for a research model that includes multiple constructs assessed across more than one dimension).

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Table 2

Sample Characteristics

Characteristic	Category	Frequency (n = 205)	Percentage (%)
Firm size (employees)	< 50 employees	52	25.4
	50 - 200 employees	102	49.8
	> 200 employees	51	24.9
Firm age	< 10 years	43	21.0
	10 - 20 years	93	45.4
	> 20 years	69	33.7
Respondent position	Owner	111	54.1
	CEO	94	45.9

Note. Results of descriptive statistics for the survey data

Before testing the structural relationship, we checked the reliability and validity of the measures. Harman's single-factor test indicated that only 21.17% of the total variance was explained by the first unrotated factor, well below the recommended threshold of 50%. This result implies that CMV does not seriously threaten the validity of our results. Examination of the external loadings indicated that all items had strong loadings on their corresponding latent factors. Three items (DE7, DE13, and DE18) had loadings below 0.4; thus, they were eliminated from the analysis. After removing these items, all other indicators showed loadings ranging from 0.705 to 0.915, indicating robust indicator reliability (Table 3).

Table 3

Outer Loadings

	CPVC	DS	DE	EL_IA	EX_IA	OE
INT	0.865					
CIT	0.915					
COP	0.892					
DS		1.000				
E1					0.709	
E2					0.724	
E3					0.705	
E4					0.745	
E5					0.735	
E6					0.806	
E7				0.732		
E8				0.725		
E9				0.762		

	CPVC	DS	DE	EL_IA	EX_IA	OE
E10				0.818		
E11				0.763		
OE1						0.865
OE2						0.734
OE3						0.709
OE4						0.767
OE5						0.790
OE6						0.796
OE7						0.878
OE8						0.845
PE			0.867			
RE			0.879			
SE			0.884			
EE			0.814			

Note. Analytical results obtained using SPSS and PLS-SEM

Internal consistency reliability was well developed, with Cronbach's Alpha values ranging from 0.781 to 0.919 and Composite (CR) scores ranging from 0.79 to 0.929. For all constructs, the AVEs exceeded the recommended threshold of 0.50, providing evidence of strong convergent validity (See Table 4). Discriminant Validity Fornell-Larcker criterion and Heterotrait-Monotrait ratio (HTMT) were checked. Three of these values, the square root of AVE for each construct, were higher than their respective inter-construct correlations, and all HTMTs were below 0.85, demonstrating that our constructs had empirical discriminant validity. To address construct multidimensionality, Digital Empowerment (DE), Customer Participation in Value Co-creation (CPVC), and Digital Servitization (DS) were modeled as higher-order constructs. The loadings on the first-order factors were strong, generally above 0.80, and the reliability and validity coefficients of the second-order variables were also satisfactory (Table 5).

Table 4

CR and AVE

	Cronbach's Alpha	CR	AVE
CPVC	0.870	0.920	0.793
DE	0.889	0.920	0.742
EL_IA	0.818	0.873	0.578
EX_IA	0.833	0.878	0.545
OE	0.919	0.934	0.640

Note. Analytical results obtained using SPSS and PLS-SEM

The viable model was then tested. Inner VIF ranged from 1.016 to 1.120 for all predictors and interaction terms, suggesting no multicollinearity. The model was highly explanatory, accounting for 53.4% of the variation in digital servitization. In comparison, operational excellence and customer involvement in value co-creation had less influence (R^2 = 0.224 and 0.230, respectively).

Table 5

Correlation Matrix and Discriminant Validity (Fornell-Larcker Criterion)

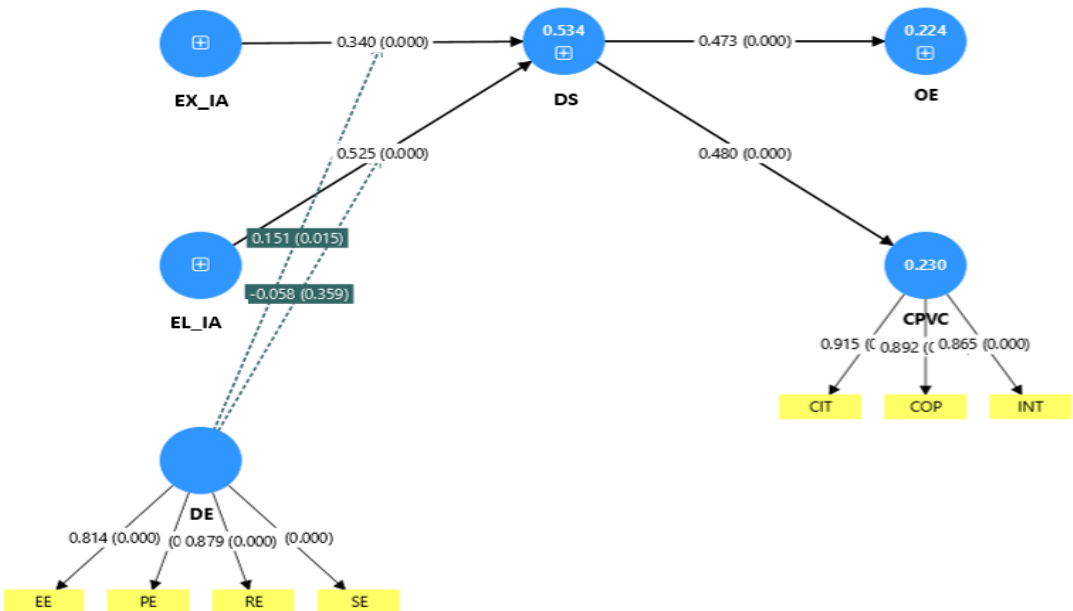
	CPVC	DS	DE	EL_IA	EX_IA	OE
CPVC	***0.891***					
DS	0.480	***1.000***				
DE	0.038	- 0.093	***0.861***			
EL_IA	0.354	0.642	- 0.047	***0.760***		
EX_IA	0.255	0.490	- 0.082	0.295	***0.738***	
OE	0.511	0.473	- 0.025	0.402	0.328	***0.800***

Note. The diagonal values are the square roots of the AVEs. Analytical results obtained using SPSS and PLS-SEM

Bootstrapping results supported most of the proposed relationships, confirming their empirical significance (Table 6). Both exploitative and exploratory innovation had positive impacts on digital servitization, with the latter having of more pronounced effect. Digital empowerment strengthened the relationship between exploitative innovation and digital servitization, but it did not have a significant moderating effect on the relationship of exploratory innovation and digital servitization. Finally, digital servitization had a significant positive impact on operational efficiency and customer involvement in value co-creation, underscoring the importance of this specific dynamic capability in SMEs.

Figure 2

Results of PLS-SEM



Note. Analytical results obtained using SPSS and PLS-SEM

The effect sizes of the relationships between exploratory and exploitative innovation factors indicated that exploration innovation had a large effect on digital servitization, while exploitative innovation had a moderate effect (Table 6). By contrast, the direct influence of digital empowerment was very low. The predictive relevance, as represented by the Stone-Geisser Q^2 values, also reinforces the strong predictive power of the model, especially for digital servitization ($Q^2 = 0.518$), followed by customer participation in value co-creation ($Q^2 = 0.175$) and operational effectiveness ($Q^2 = 0.138$) (Table 7).

Table 6

Structural Model Results and Hypothesis Testing

Hypothesis	Path	β	T-value	P-value	Supported
H_{1a}	EX_IA → DS	0.34	6.579	< 0.001	Yes
H_{1b}	EL_IA → DS	0.525	11.878	< 0.001	Yes
H_{2a}	DE × EL_IA → DS	- 0.058	0.917	0.359	No
H_{2b}	DE × EX_IA → DS	0.151	2.423	0.015	Yes
H_3	DS → OE	0.473	8.958	< 0.001	Yes
H_4	DS → CPVC	0.48	8.866	< 0.001	Yes

Note. Analytical results obtained using SPSS and PLS-SEM

Table 7

Model Quality Metrics (R^2, Q^2, and Effect Sizes f^2)

Endogenous Construct	R^2	Adjusted R^2	Q^2	Key f^2 Contributions
Digital Servitization (DS)	0.534	0.522	0.518	EL_IA = 0.529; EX_IA = 0.221; DE = 0.005; DE × EX_IA = 0.044
Operational Effectiveness (OE)	0.224	0.22	0.138	DS = 0.289
Customer Participation in Value Co-creation (CPVC)	0.23	0.226	0.175	DS = 0.299

Note. All Q^2 values are positive, indicating predictive relevance of the model's predictive relevance; the magnitude of Q^2 differs across constructs, with digital servitization exhibiting strong predictive relevance and performance outcomes showing small-to-medium levels. Analytical results obtained using SPSS and PLS-SEM

Although mediation effects were not explicitly hypothesized, we examined whether Digital Servitization (DS) transmits the effects of exploratory innovation (EX_IA) and exploitative innovation (EL_IA) to the two outcome constructs, Operational Effectiveness (OE) and Customer Participation in Value Co-creation (CPVC). Following recommended PLS-SEM procedures, we assessed the specific indirect effects using bootstrapping (5,000 subsamples) and evaluated their significance based on bias-corrected confidence intervals (Hair et al., 2019; Preacher & Hayes, 2008).

Table 8

Specific Indirect Effects (Mediation Analysis)

Indirect effect	β (indirect)	T-value	P-value	95% BCa CI
EL_IA → DS → OE	0.248	6.841	< 0.001	[0.178, 0.318]
EX_IA → DS → OE	0.161	5.167	< 0.001	[0.102, 0.226]
EL_IA → DS → CPVC	0.252	6.750	< 0.001	[0.178, 0.325]
EX_IA → DS → CPVC	0.163	5.187	< 0.001	[0.104, 0.228]

Note. Analytical results obtained using SPSS and PLS-SEM

The estimated indirect effects are positive, suggesting that DS functions as a key mechanism linking both dimensions of innovation ambidexterity to internal (OE) and relational (CPVC) outcomes. Because the structural model does not specify direct paths from EX_IA/EL_IA to OE or CPVC, statistically significant indirect effects would be consistent with an indirect-only (full) mediation pattern in which innovation capabilities influence performance outcomes primarily through digital servitization.

As shown in Table 8, all four specific indirect effects are positive and statistically significant ($p < 0.001$), and the 95% bias-corrected confidence intervals do not include zero. Moreover, the indirect effects associated with exploitative innovation are larger than those associated with exploratory innovation, suggesting that incremental refinement and scaling activities may translate into stronger digital servitization, thereby improving both operational effectiveness and customer participation in value co-creation.

5. Conclusion

These results show that both exploitative innovation (EL) and exploratory innovation (EX) are positively associated with digital servitization (DS) ($\beta\_EL \rightarrow DS = 0.525$; $\beta\_EX \rightarrow DS = 0.340$, $p < 0.001$). The stronger role of exploitative innovation suggests that, in Vietnamese manufacturing SMEs, DS is often advanced through incremental upgrading, standardization, and scaling of existing solutions under resource constraints. At the same time, the significant exploration effect indicates that experimentation and the search for new digital service opportunities remain important for building DS capabilities. Overall, these findings are consistent with the dynamic capabilities view that ambidexterity helps firms' sense, seize, and reconfigure resources toward digitally enabled service business models (He & Wong, 2004; Teece, 2007). Digital Empowerment (DE) exhibits an asymmetric moderating role. The interaction term DE × EX is positive and significant ($\beta = 0.151$, $p = 0.016$), whereas DE × EL is not significant ($\beta = - 0.058$, $p = 0.359$). This pattern suggests that empowerment mechanisms (e.g., access to digital tools and data, enabling platforms, supportive structures, and decision autonomy) primarily help SMEs translate exploratory initiatives into DS by lowering experimentation costs and accelerating learning cycles. In contrast, exploitative, innovation-focused on refinement and routinization, appears less contingent on empowerment and may rely more on process discipline and operational routines. DS is positively related to both Operational Effectiveness (OE) ($\beta\_DS \rightarrow OE = 0.473$, $p < 0.001$) and Customer Participation in Value Co-creation (CPVC) ($\beta\_DS \rightarrow CPVC = 0.480$, $p < 0.001$). Internally, digitized service processes improve visibility, coordination, and responsiveness, strengthening planning and execution. Externally, digitally enabled touchpoints (e.g., portals, remote monitoring, and shared

dashboards) facilitate interaction and collaborative problem solving, increasing customer participation. Hence, DS functions as a bridging capability that improves both internal operations and relational value creation. Consistent with this mechanism view, the bootstrapped specific indirect effects in Table 8 are all positive and significant: EL → DS → OE (β = 0.248), EX → DS → OE (β = 0.161), EL → DS → CPVC (β = 0.252), and EX → DS → CPVC (β = 0.163) (all $p < 0.001$; 95% BCa CIs exclude zero). Because the model does not include direct paths from EL/EX to OE or CPVC, these results indicate an indirect-only mediation pattern in which innovation capabilities influence performance outcomes primarily through DS (Hair et al., 2019; Preacher & Hayes, 2008).

This study contributes to digital servitization and innovation ambidexterity literature in three ways. First, by distinguishing exploratory and exploitative innovation within innovation ambidexterity, we show that both dimensions foster digital servitization in manufacturing SMEs, with exploitative innovation exerting a stronger effect under resource constraints. This refines prior arguments by indicating that, in emerging-economy SME contexts, digital servitization is often advanced through incremental upgrading, standardization, and scaling of existing solutions while still benefiting from exploratory search. Second, we theorize and empirically demonstrate digital empowerment as a boundary condition shaping the conversion of innovation efforts into digital servitization. The results reveal an asymmetric pattern: digital empowerment strengthens the effect of exploratory innovation on digital servitization but does not significantly condition the exploitative path, thereby extending contingency explanations in digital transformation and dynamic capabilities research. Third, we broaden the outcome domain of digital servitization by linking it to both operational effectiveness and customer participation in value co-creation, and by reporting significant specific indirect effects through digital servitization. These findings clarify digital servitization as a mechanism through which innovation capabilities translate into both internal operational improvement and relational value creation in an emerging-economy setting.

The findings provide several implications for managers of manufacturing SMEs. Firms should pursue a balanced portfolio that combines scaling-oriented exploitative innovation with targeted exploration innovation. Exploitative efforts - such as standardizing digital service processes, improving reliability, and replicating proven solutions across customers - appear particularly effective in advancing digital servitization under constrained resources. At the same time, exploratory initiatives remain essential for identifying new digitally enabled service opportunities. Importantly, managers should invest in digital empowerment to unlock the value of exploration: improving access to digital tools and data, establishing enabling platforms for collaboration, and delegating appropriate decision autonomy can reduce experimentation costs and accelerate organizational learning. Finally, managers can leverage digital servitization not only to improve internal operations but also to deepen customer collaboration. Implementing connected-service solutions (e.g., remote monitoring and shared dashboards) and formalizing data-sharing and joint problem-solving routines with key customers can enhance operational effectiveness and strengthen customer participation in value co-creation.

However, this study has limitations. First, the cross-sectional design and single-informant survey limit causal inference and may still be subject to residual common-method bias, despite procedural remedies and collinearity checks. Future research should use longitudinal designs, multi-respondent data, and objective indicators of digital service outcomes. Second, the sample focuses on Vietnamese manufacturing SMEs; replication across industries and countries would strengthen generalizability and enable comparative tests of

institutional conditions. Third, future work could examine additional contingencies (e.g., market orientation or digital infrastructure maturity) and examine mechanisms that moderate mediation to unpack further how innovation ambidexterity is translated into digital servitization and performance.

In sum, the findings indicate that innovation ambidexterity is a key antecedent of digital servitization in Vietnamese manufacturing SMEs. Digital empowerment selectively strengthens the exploratory innovation-digital servitization link, and digital servitization, in turn, improves operational effectiveness and customer participation in value co-creation while mediating the effects of innovation capabilities on these outcomes.

SCIENTIFIC CONTRIBUTION

The manuscript clearly identifies a research gap; the manuscript extends/refines existing theories; the manuscript proposes a new theoretical/analytical model; the manuscript introduces/improves research methods; the manuscript provides new datasets/empirical evidence; the manuscript presents statistically and practically significant findings; the manuscript offers policy/managerial/technological implications; the manuscript opens new directions for further research.

AUTHOR CONTRIBUTIONS

CRediT: **Nguyen Ngoc Thong**: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing - Original Draft, Project Administration; **Kieu Anh Tai**: Conceptualization, Methodology, Validation, Writing - Review & Editing, Supervision.

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NO CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

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