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Influence of digital ambidextrous capabilities on SMEs' transformation performance: The mediating effect of business model innovation

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ABSTRACT

As the global digital transformation process accelerates, how SMEs can successfully achieve digital transformation is currently an important research question in the field of strategic management and a real-life dilemma that entrepreneurs need to address. This study classifies business model innovation into market-driven business model innovation and driving-market business model innovation based on market orientation theory. The relationship between digital ambidextrous capabilities, business model innovation and transformation performance is explored according to the paradigm of 'capability-behaviour-performance'. This study used SEM and fsQCA to analyze 289 questionnaires collected from middle and senior managers of Chinese SMEs. The results show that digital exploitation capability is positively associated with market-driven business model innovation, while digital exploration capability is positively associated with driving-market business model innovation. In particular, business model innovation plays a fully mediating role in the process of digital ambidextrous capabilities enhancing the transformation performance. Our findings shed new lights on the current debate surrounding the digital transformation of SMEs and will be instructive for both academics and business managers.

1. Introduction

Digital technologies such as big data, Internet of Things, Cloud Computing, Artificial Intelligence, continue to break through and converge, driving the digital economy era [1,2]. Companies integrate internal and external resources through digital technologies to reshape their vision, strategy, organizational structure, processes, capabilities, and culture, so that they can adapt to the dynamically changing market environment and gain sustainable competitive advantage [3,4]. Due to limited resources and capabilities, when SMEs start their digital transformation, their initial goal is usually to use resources more effectively and to improve efficiency in all aspects of management with digital technologies [5], such as combining digital technologies with traditional IT systems (e.g. ERP, OT systems) to improve efficiency and using big data to optimize processes to reduce costs [6,7]. Over time, as SMEs redesign their products or processes with digital technologies, alongside those activities are some exploration activities [8], such as using new technologies for product innovation and forecasting potential customer needs. However, too much focus on exploration or exploitation activities can make companies vulnerable to the 'capability' or 'failure' trap. In order to achieve a competitive advantage, firms must balance both exploration and exploitation activities to eliminate the binary paradox [9].

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Organizational ambidexterity theory states that a firm can only achieve longevity if it has the ambidextrous capabilities to simultaneously develop existing businesses and explore new ones [10,11]. However, existing studies do not agree on whether ambidextrous capabilities are beneficial to the growth of SMEs [12,13]. Ambidextrous capabilities also have the characteristics of dynamic capability, thus enabling SMEs to become more flexible and agile to adapt to a dynamically changing environment [13], ultimately improving business performance by easing the binary tensions in the transformation process [14–16]. Previous literature has limited research on achieving organizational flexibility in the digital context [17]and the tension between how to manage exploration and exploitation activities is still not effectively addressed [18]. Therefore, this paper attempts to incorporate digital ambidextrous capabilities into the research framework based on organizational ambidexterity theory and dynamic capability theory. According to Zhen et al. [19]and Alberto et al. [20], digital ambidextrous capabilities can be defined as the dynamic ability to balance exploration and exploitation activities simultaneously. Furthermore, digital exploitation capability refers to developing existing businesses with the help of digital technologies, and digital exploration capability refers to exploring new businesses with the help of digital technologies.

Digital transformation does not directly improve transformation performance but rather drives companies to rethink and transform their business models [21]. A growing number of scholars advocate an in-depth exploration of the innovation logic and mechanisms of business models in digital contexts [22,23]. The digital transformation process is a strategic market-oriented decision [24], which is also accompanied by business model innovation [25]. Based on market orientation theory, business model innovation is classified into market-driven business model innovation and driving-market business model innovation [26]. Market-driven business model innovation is based on existing market demand and focuses on improving existing transaction structures [27]. Driving-market business model innovation proactively creates value for customers based on latent market demand, resulting in higher profits [28]. As market-driven business model innovation and driving-market business model innovation are contradictory ambidextrous needs, which shares similarities with the characteristics of digital ambidextrous capabilities, so how do digital ambidextrous capabilities interact with business model innovation? Specifically, based on similar characteristics, what are the mechanisms of interaction between digital exploitation capability and market-driven business model innovation, and between digital exploration capability and driving-market business model innovation, respectively? This is the reason why this study classifies digital ambidextrous capabilities. In addition, business model innovation is most directly reflected in improved firm performance [29], but less research has been conducted in the context of digital transformation, and these questions are needed to be further discussed.

Digital ambidextrous capabilities, as a dynamic capability, are also closely related to business model innovation. Indeed, it may be crucial to explain the impact of business model innovation on SME performance from the perspective of exploitation and exploration. However, insights on the relationship of digital ambidextrous capabilities and transformation performance, especially linked to business model innovation, have been less available so far. More importantly, SMEs are unique in terms of industry, size, ownership, and stage of maturity, and the business model innovation of large companies may not be suitable for SMEs. Therefore, exploring SMEs' business model innovation is of great relevance to the development of the digital economy [31].

Based on previous research processes, this study aims to examine how digital ambidextrous capabilities can influence SMEs' transformation performance through business model innovation. Therefore, we surveyed 289 middle and senior managers from Chinese SMEs, Combining two methods, structural equation modeling (SEM) and fuzzy set qualitative comparative analysis (fsQCA). The findings show that SMEs with digital ambidextrous capabilities can innovate their business models based on market orientation to improve transformation performance. Our results shed new managerial light on the SMEs' digital transformation today, and expand the scope of research on organizational ambidexterity theory, dynamic capability theory, and market orientation theory, and provide new perspectives on the future research for academics and management practitioners.

2. Theoretical background and hypotheses

2.1. Digital ambidextrous capabilities

In the digital economy era, digital competence determines the extent to which a company exploits and explores digital technologies [30]. Annarelli et al. consider digital capability as a dynamic ability to fully integrate a company's resources and capabilities to innovate products, services and processes with digital technology, which can adapt to a dynamically changing and unpredictable digital environment [3,31]. Digitalization is often introduced by companies to digitize business processes for improved operational efficiency, as well as to accelerate information sharing and knowledge flow for multi-departmental collaboration, which will contribute positively to both exploitative operations and exploratory innovation. As a result, digital capability is empowered with ambidexterity [20], and digital ambidextrous capabilities enable exploration and exploitation activities to be more effectively advanced by leveraging digital technologies. On the one hand, digital exploitation capability increases the efficiency of existing operational processes, such as using the internet to enable diverse communication with other partners to reduce R&D costs and using digital resources to reconfigure business models and value networks. On the other hand, digital exploration capabilities can explore future markets to gain a competitive advantage [3], such as forecasting future markets and creating new products and services with digital technologies such as big data.

The widespread digitalization of companies has complicated the mechanisms for achieving organizational ambidexterity [32]. In recent years, academics have begun to discuss the question of ambidexterity in a digital context [33,34], but few studies have been conducted to explain which new mechanisms arise from digital ambidextrous capabilities. Previous research on digital capabilities has mainly focused on conceptual definition, theoretical traceability, organizational change, strategic management, operational models, and value creation [17,36]. In order to analyze the mechanism of action of digital ambidextrous capabilities, we refer to existing findings [20]and refine the digital ambidextrous capabilities into digital exploitation capability and digital exploration capability. Digital exploitation capability means using digital technology to redesign products, services, and processes to meet existing market needs, which can drive exploitation innovation; digital exploration capability means using digital technology to design new products, services, and processes to forecast future market needs, which can drive exploration innovation.

2.2. Business model innovation

Digital transformation is essentially using digital technologies to innovate business models and provide new sources of revenue as well as opportunities for value creation [37,38]. Previous research has confirmed that the key to the different economic performance of companies producing similar products to meet the same customer needs is the adoption of radically different business models based on product market strategies [31]. Market orientation theory states that companies react in two ways when faced with market changes: market-driven or driving-market [26], which describes two types of strategic decisions to passively adapt to the market and actively influence the market, driving SMEs to engage in customer-led business model innovation [39]. Unfortunately, the relationship between digital ambidextrous capabilities and business models, and the impact of business model innovation has rarely been explored, and there remains a particular lack of research on SMEs. Therefore, this study follow Randhawa et al. and consider that business model innovation can specifically be divided into two approaches: passive adaptation to the market (market-driven business model innovation) and active influence on the market (driving-market business model innovation) [39].

Market-driven business model innovation is an adaptive development activity that passively transforms existing knowledge and adapts transaction structures based on existing market demand, continuously in response to customer demands [39,40]. Driving-market business model innovation is an active exploration activity based on potential market needs and customer preferences, proactively allocating corporate resources to create new value and new transaction structures, and even open new markets [39,40]. Furthermore, these two business models are not contradictory, but interdependent, dynamically adapting to the changing market through mutual coordination [41]. Many scholars have discussed how to advance business model innovation from organizational ambidexterity [42], resource restructuring aspects [43], and dynamic capability perspectives [39], but few scholars have focused on market-oriented business model innovation in the digital context [40].

2.3. Transformation performance

There is a disruptive impact of applying digital technologies on the companies' production methods, business models, and performance [29,36]. The initial aim for SMEs' digital transformation is to leverage digital technologies such as cloud computing and big data to optimize their business processes and strengthen collaborative relationships between internal and external parties, thereby reduce production costs and improving operational efficiency [44]. Along with the deep application of digital technology, it will accelerate changes in the innovation structure of the product value chain, and companies can use digital technology to predict future market demand to innovate products and services and improve innovation performance [5,30]. However, digital transformation presents both opportunities and challenges. Previous discussions in the literature on how digital transformation affects business performance can be divided into two main aspects: firstly, digital transformation can improve the whole process business with digital technology, which drives technological innovation and service innovation to achieve digital manufacturing, and brings a positive impact on business performance [45]; secondly, digital transformation requires companies to have the appropriate capabilities and resources, as digital technology may be difficult to integrate with companies' existing resources, which may be difficult to integrate and reorganize, thus generating significant management costs and severely weakening the effect of digital transformation on driving business performance [46]. More importantly, there is a consensus that digital transformation does not directly affect firm performance and that business model innovation plays a key role [8].

2.4. Hypotheses

2.4.1. Digital ambidextrous capabilities and business model innovation

Digital exploitation capability means the capability to exploit existing digital technology resources and practices to improve the efficiency of an organization's existing processes. SEMs are more vulnerable than large companies in the process of digital transformation and should take a more stable approach to business model innovation. Digital exploitation capability refines, exploits, and develops existing knowledge and data resources to continuously improve existing digital products, services, and skills in response to the needs of existing customers [20]. When companies have digital exploitation capabilities, they can better integrate human, knowledge and technology resources, obtain more accurate market and customer information to redesign existing business processes, innovate ways to create value [47], as well as reduce risks of changing transaction structures and profit sharing schemes. Digital exploitation capability can also maintain a company's existing organizational and staff structure to innovate on maintaining the existing business model. This is an adaptive development approach geared towards market and user needs, which will drive organizations towards market-driven business model innovation in an evolutionary process [48].

Digital exploration capability means the capability of SMEs to explore potential digital resources as well as to explore new resources. This provides SMEs with diverse knowledge and innovation opportunities, promotes new innovative practices, develops new transaction structures and distribution channels, and facilitates the opening of new markets [49]. Digital exploration capability enable companies to continuously search, acquire and innovate, use digital technologies, and share information and resources among value network members [20]. Digital exploration capability drives SMEs to acquire new resources to invest in their business models, continuously develops new products and create new demand, and promotes the market in a direction that facilitates their growth and higher performance. For example, Amazon and Walmart have introduced digital technologies to develop new supply chains for new transaction structures, and Sam's Supermarket has opened up new member market structures by developing an online membership management system, ultimately promoted driving-market business model innovation through digital exploration capability.

In sum, we propose the following hypothesis.

H1a. Digital exploitation capability is positively associated with market-driven business model innovation.

H1b. Digital exploration capability is positively associated with driving-market business model innovation.

2.4.3. The mediating role of business model innovation

SMEs are vulnerable to risk and need to be more careful in optimizing their business processes and creating a relatively stable environment as far as possible during the digital transformation process [36,39]. Digital exploitation capability can enhance the utilization of existing resources and knowledge, improve and complete existing business processes, and effectively reduce time and operational costs [53,57]. However, the resources captured by the digital exploitation capability do not directly impact performance, because they are not commercialized and generate value. To capture this value, it is necessary to deploy these resources through a suitable business model. Market-driven business model innovation efficiently utilizes available resources to enhance and improve existing business and transaction structures [26], which improves SMEs' efficiency in generating profits and gains high transformation performance in a dynamic environment [58].

SMEs with digital exploration capability can quickly grasp information about the external environment, explore the diverse consumer needs and potential market gaps, as well as transform and upgrade their processes and operations [55], and drive the market in a direction more conducive to their survival [51]. SMEs will focus on future opportunities and challenges in the market, and their size is more suited to creating flexible organizational structures and business processes [33], thus avoid 'obsolescence' in a rapidly changing market. Especially when faced with new opportunities, SMEs with digital exploration capabilities can proactively adopt innovative business systems to leapfrog customer value and be 'one step ahead' in driving the digitalization of their businesses, and gain sustainable advantages and transformation performance [39].

In sum, we propose the following hypothesis.

H3a. Market-driven business model innovation mediates the relationship between digital exploitation capability and transformation performance.

H3b. Driving-market business model innovation mediates the relationship between digital exploration capability and transformation performance.

Based on the above hypotheses, the hypothesized model is obtained as shown in Fig. 1.

2.4.2. Business model innovation and transformation performance

Market-driven business model innovation reflects an exploitative behavior in which SMEs passively improve existing technology and organizational processes based on existing market demand, which in turn improves the efficiency of existing operations and service levels [40,50]. Market-driven business model innovation can improve stability in the development and operation process, and exploit existing markets through exploitative learning, which will not only lower research costs, but also reduce potential errors in the problem-solving process [26]. Furthermore, market-driven business model targets existing customer segments, enable a shorter time to market and market penetration [51], and achieve faster customer response and a more stable cash flow, especially in dynamic environments [52]. This exploitative behavior in response to the market has effectively improved transformation performance: For example, companies use digital technologies such as big data and cloud computing to integrate internal knowledge, experience, ideas and external resources in order to quickly and accurately identify explicit and invisible needs [53]; digital twin solutions enable companies to create digital simulation models that reduce costs, minimise investment risks and increase business productivity [54], etc. In conclusion, market-driven business model innovation can reduce risks and costs, bring more stable business benefits, and improve transformation performance.

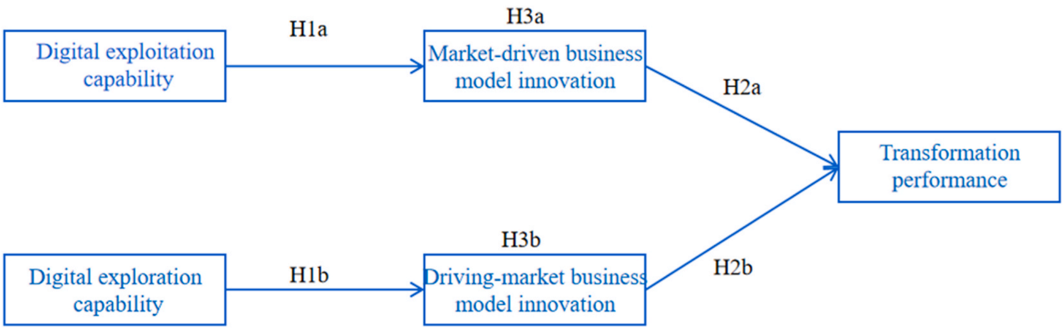

Fig. 1. Theoretical model.

Driving-market business model innovation reflects that SMEs will proactively change market structures and market behaviors, focus on future markets and new competitive opportunities, tend to create flexible organizational structures and processes, drive innovation and discovery, which is an explorative behavior [40]. SMEs can either introduce new products and services into (new or existing) markets, create entirely new markets, or even disrupt an industry by driving-market business model innovation to transform positively. This will not only bring new revenue-generating projects, but also gain higher profits in the absence of competitive products [26]. Furthermore, driving-market business model innovation can seize new opportunities to create a leap in customer value by building new business systems [55], and building long-term intangible value with customers in future market segments, which will provide companies with future cash flow and sustainable competitive advantage [51]. This driving-market business model innovation is particularly important for SMEs to avoid 'obsolescence', especially in the rapidly changing digital environment [56], which can have a positive impact on transformation performance.

In sum, we propose the following hypothesis.

H2a. Market-driven business model innovation is positively associated with transformation performance

H2b. Driving-market business model innovation is positively associated with transformation performance

3. Research methodology

3.1. Study sample and data collection

This study conducted a questionnaire survey of SMEs in various industries in the country from December 2021 to March 2022. Considering that digital transformation is a strategic issue for companies, this sample frame used for the study was restricted to middle and senior managers of SMEs. The questionnaire was contacted by MBA students from universities and professional market research organizations. We contacted five senior and middle managers of SMEs for a pre-study, and invited academics in the field of digital transformation and business model innovation to revise and adjust the language based on the feedback from the questionnaire before forming the final formal questionnaire, to ensure the rigor of the questionnaire and that the respondents could understand and answer the questions accurately. A total of 400 questionnaires were sent out via WeChat and email, and after several contacts and reminders, 383 questionnaires were returned. However, several invalid questionnaires were included (those with obvious regularity of responses and those with a response time of less than 1 min), and before the data analysis was carried out, a total of 289 questionnaires were retained after elimination, with a validity rate of 72.25 %.

The questionnaire's scales are drawn from well-established scales in the published literature and were translated and localized by contacting two professors in the field of strategic management. It is divided into three main sections, the first of which has a skip question item to screen the respondents. The second part looks at general information about the company (e.g. type of industry, age of the company, number of employees, etc.). The third part specifically investigates the research variables, including digital exploitation capability, digital exploration capability, market-driven business model innovation, driving-market business model innovation and transformation performance (see Appendix 1).

As the companies surveyed came from several industries, it was not easy to classify the size according to a uniform standard according to the China SME Classification Standard, so we used a questionnaire to ensure that the research respondents were from SMEs. Our questionnaire is aimed at middle and senior managers of SMEs who have been managing their businesses for a long time and who have a good understanding of the size and strategic management of their companies. In order to filter the questionnaire from SMEs, we set the first question "Is your company an SME? "(if yes, answer the questions in order; if no, end the questionnaire), thus ensuring that the data we receive is valid.

The descriptive information statistics of the questionnaires is shown in Table 1. In particular, referring to Wu et al.'s approach to select keywords for digital transformation [59], five keywords such as big data analysis, database, cloud computing, artificial intelligence, and the Internet of Things were identified as markers for companies undertaking digital transformation. The companies surveyed have adopted one or more digital technologies, demonstrating that they are in the process of or have already entered the digital transformation process. Meanwhile, companies in this research come from Chinese Internet, finance, infrastructure, service, and energy industries, which can reflect a certain extent the digital transformation of Chinese SMEs with strong representation and research value.

Table 1
Basic information about the sample companies.

Variables	Classification	Number	Percentage	Variables	Classification	Number	Percentage
Company size	Under 100 staff	110	38.06	Number of years in the company	Less than 5 years	69	23.88
	100-500 staff	81	28.03		5–10 years	78	26.99
	500-1000 staff	24	15.57		10–15 years	35	12.11
	1000-3000 staff	74	8.30		More than 15 years	107	37.02
Nature of the company	State-owned	91	31.49	Digital technology	Big Data Analysis	168	58.13
	Private	148	51.21		Databases	225	77.85
	Joint Ventures	19	6.57		Cloud Computing	128	44.29
	Foreign investors	15	5.19		Artificial Intelligence	113	39.10
	Other	16	5.54		Internet of Things	124	42.91

3.2. Measures

This study refers to well-established scales which have been measured and proven to be effective. Of these, digital exploitation capability and digital exploration capability are mainly adapted from the study by Chi et al. combined with Chinese SMEs' digital transformation scenarios, including six question items [60]. Market-driven business model innovation and driving-market business model innovation referencing Liao et al.'s study, which were measured from three dimensions of value creation, market competition, and transactional relationships, including six question items [40]. Transformation performance was referred to in the study by Zheng et al., which were measured from three dimensions of sales, market share, and profit growth, including three question items [61]. The above 15 questions constitute the final scale for this study (Table 2), which was investigated using the Likert 5-point scale method.

For this study, two generally accepted control variables were selected: size and age. Size refers to the number of employees in the firm and age refers to the number of years since the establishment of the firm [62].

3.3. Data analysis

We combined structural equation modeling(SEM) with Fuzzy set qualitative comparative analysis(fsQCA) to examine our hypothesis and analyzed the data using three software packages, AMOS 24.0, SPSS 26.0, and fsQCA 3.0. These two approaches are based on different technical principles and, although they have different emphases, can have complementary effects. SEM is primarily used to analyze causal relationships, particularly the net effect of independent variables on dependent variables, and to explain direct and indirect solution effects between variables. fsQCA is based on a holistic analysis of multiple concurrent causal relationships, enabling further insights into the complex mechanisms of action of all the variables in the study affecting the transformation performance of SMEs, compensating for the SEM which can only analyze a single causal relationship. Thus, combining these two research methods will ensure that the research model matches the empirical data and improve the credibility of the results.

3.4. Validation factor analysis and homology bias

Since we measured all items via the same self-report questionnaire, common methodological biases may threaten the interpretation of the study results. Therefore, we used Harman's one-factor test to check for potential common method bias [63]. An exploratory factor analysis of all items in the model showed that four factors had eigenvalues greater than 1. In addition, the first factor explained 40.954 % of the variance. This variance is less than 50 %, so it is unlikely that common method bias exists. In addition, the VIF values for the regression analyses in this paper are all less than 2, indicating that the research model is well constructed and there is no problem of multicollinearity [64]. More importantly, the questionnaires were mainly distributed online through MBA students and professional market research agencies, with each questionnaire coming from a different company (multi-channel and multi-source

Table 2
Items and scales.

Variables	Title item	Factors Loadings	Cronbach's α	AVE	CR
Digital exploitation Capability	Digital technology helps our company to effectively support the overall objectives of the business today	0.794	0.829		
	Our company can effectively leverage relevant resources and drive digital transformation	0.791		0.618	0.829
	Our company can effectively use digital technology to optimize existing business activities	0.773			
Digital exploration capabilities	Digital technology helps our company to respond flexibly to market changes today	0.760	0.847		
	Our company can quickly adapt and upgrade to business changes with digital technology	0.863		0.650	0.848
	Our company can use digital technology to facilitate R&D activities in response to changes in the external environment	0.793			
Market-driven Business model innovation	Our company sets business goals based on market and customer needs	0.756	0.844		
	Our company has increased its existing market share in the course of digital transformation	0.835		0.645	0.845
	Our company has improved the efficiency of existing transactions in the course of digital transformation	0.816			
Driving-market Business model innovation	Our company is able to constantly explore and explore the potential needs of the market and our customers	0.791	0.853		
	Our company is committed to opening up and capturing new markets in the process of digital transformation	0.860		0.660	0.853
	Our company creates new trading relationships by developing new products	0.783			
	Higher sales growth for our company than before the digital transformation	0.811	0.883		
Transformation performance	Higher market share growth for our company than before the digital transformation	0.825		0.683	0.866
	Higher profit growth for our company than before the digital transformation	0.843			

Notes: AVE -average variance extracted; CR-composite reliability.

collection of questionnaires), which to a certain extent reduces the problem of common method bias.

3.5. Reliability and validity analysis

To ensure the reliability and validity of this study, the corresponding tests were conducted and the results were shown in Tables 2 and 3. In this study, the reliability and validity of the questionnaire were tested using SPSS 26.0. Firstly, the reliability of the scale was tested by calculating Cronbach's alpha coefficient. The Cronbach's alpha coefficient for each scale was greater than 0.8, and the overall reliability of the questionnaire was high [65]. KMO and Bartlett's sphericity tests were conducted and the KMO value was 0.870 and Bartlett's sphericity test significance level was 0.000, indicating that the items had a high level of internal consistency and were suitable for factor analysis [66].

We also conducted a validity test using the AMOS 24.0. Firstly, the questionnaire is based on a well-established scale, which ensures content validity. The factor loadings for each variable measured were above 0.6, indicating that the question items corresponding to each latent variable were highly representative [67]. Secondly, the combined reliability of all variables was greater than 0.8 and the AVE values were all above 0.6, so the convergent validity of the scale was good. Finally, the AVE's square root values are greater than the correspondent correlations of all factors, which means that the indices are related to their factors greater than others. Therefore, the discriminate validity is attained [68].

3.6. Measurement model

Discriminant validity tests and model fitting were carried out with AMOS 24.0. As shown in Table 4, the original model fit indicators all met the fit criteria and outperformed the other models, indicating some discriminant validity between the variables, and passed the chi-square test at a significance level of 0.001, indicating that the discriminant validity of the scales was satisfactory. In addition, the $\chi2/df = 1.986$, RMSEA = 0.059, NFI, GFI and CFI are all greater than 0.9, PCFI and PNFI are all greater than 0.5, the overall fit values are within the reference range and the overall fit of the model is good, indicating that the model fit of the predetermined relationship is ideal and can be hypothesis tested [69].

4. Empirical results

4.1. Hypothesis testing

The study uses AMOS 24.0 for hypothesis testing. As shown in Table 5 and Fig. 2, the p-value of path L1 is less than 0.001, indicating that the positive association of digital exploitation capability with market-driven business model innovation is very significant, thus H1a is true; the p-value of path L2 is less than 0.001, indicating that the positive association of digital exploration capability with driving-market business model innovation is also very significant, thus H1b is true. The p-value for path L3 is less than 0.001, the positive association of market-driven business model innovation with transformation performance is very significant, thus H2a is true; the p-value for path L4 is less than 0.001, indicating that the positive association of driving-market business model innovation with transformation performance is also very significant, thus H2b is true.

In addition, we constructed two paths, "digital exploitation capability → transformation performance" and "digital exploration capability → transformation performance", and the p-values for these two paths were 0.231 and 0.092 respectively, both of which were greater than 0.05, indicating that neither digital exploitation capability nor digital exploration capability can have a direct impact on the transformation performance. Combining H1a, H1b, H2a and H2b, it is inferred that business model innovation plays a fully mediating role in the influence of digital ambidextrous capabilities on the transformation performance, thus H3a and H3b is true.

4.2. Bootstrap

The study uses AMOS 24.0 for Bootstrapping, results are shown in Table 6. To further verify the mediating role of business model innovation, this study adopts the bootstrap interval method to test the mediating effect. If the confidence intervals of Bias-corrected and Percentile do not contain 0, it means that the mediating effect exists [70]. The corresponding mediating effect values and confidence intervals were estimated by self-sampling 5000 bootstrap samples, and the results were obtained as shown in Table 6. The confidence intervals at the 95 % level are (0.155, 0.378) and (0.152, 0.373) for market-driven business model innovation, (0.127,

Table 3
Analysis of discriminant validity.

	M	SD.	1	2	3	4	5
Digital exploration capability	4.0865	0.6988	**0.786**				
Digital exploitation capability	4.0842	0.7408	0.352	**0.806**			
Diving-market business model innovation	3.9723	0.7647	0.385	0.136	**0.803**		
Market-driven business model innovation	3.9100	0.7839	0.186	0.528	0.072	**0.826**	
Transformation performance	3.9262	0.7905	0.403	0.433	0.583	0.572	**0.812**

Notes: AVE's square root is shown in bold. M-average value; SD−standard deviation.

Table 4
Result of confirmatory factor analyses (CFA) and chi-square difference test.

Models	factors	χ^2	χ2/df	RMSEA	NFI	CFI	$\Delta\chi^2$	P-value
Original model	DL,DR,MD,DM,TF	115.787	1.447	0.039	0.952	0.985		***
Four-factor model	DL,DR,DM,MD + TF	276.710	3.294	0.089	0.886	0.917	160.923	***
Three-factor model	DL,DR,MD + DM + TF	442.056	5.081	0.119	0.818	0.847	326.269	***
Two-factor model	DL,DR + MD + DM + TF	667.372	7.499	0.150	0.725	0.751	551.585	***
One-factor model	DL + DR + MD + DM + TF	973.010	10.811	0.185	0.599	0.619	857.223	***

Note: *** represents P < 0.001; DL = digital exploitation capability; DR = digital exploration capability; MD = market-driven business model innovation; DM = driving-market business model innovation; TF = transformation performance. "+"represents integration.

Table 5
Path coefficients and hypothesis testing.

No.	Paths	Estimate	P-value	Hypothesis testing
L1	Digital exploitation capability → Market-driven business model innovation	0.528	***	Acceptance
L2	Digital exploration capability → driving- market business model innovation	0.385	***	Acceptance
L3	Market-driven business model innovation → Transformation performance	0.470	***	Acceptance
L4	Driving-market business model innovation → Transformation performance	0.507	***	Acceptance
L5	Digital exploitation capability → Transformation performance	0.079	0.231	Rejection
L6	Digital exploration capability → Transformation performance	0.096	0.092	Rejection

Note: P-value less than 0.05 is considered significant, *** means P-value less than 0.001.

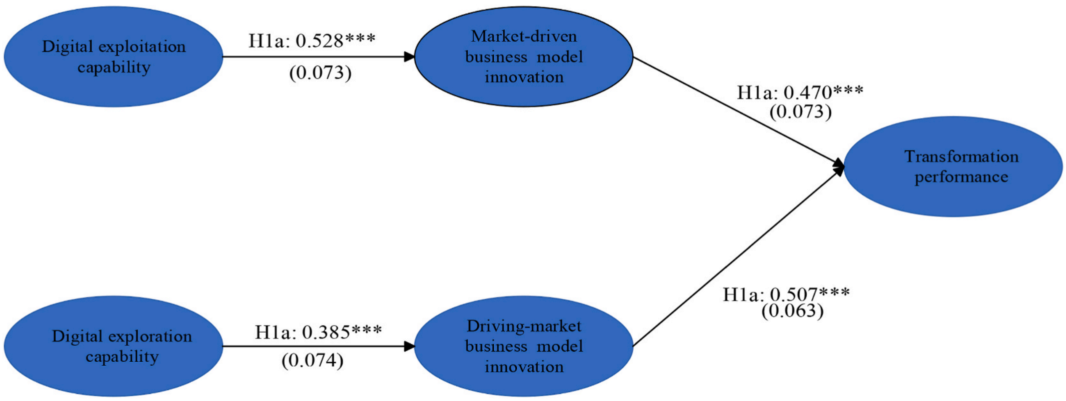

Fig. 2. SEM results of the hypothesized model.
Notes: the figure shows the standardized coefficients, with standard errors in the parentheses.
***p < 0.001. We have omitted size and age control variables in order not to complicate the figure.

Table 6
Bootstrap intermediate effects test.

Paths	Effect value	SE	Bootstrapping			
			Bias-corrected 95 % CI		Percentile 95 % CI	
			Lower	Upper	Lower	Upper
Digital exploitation capability → Market-driven business model innovation → Transformation performance	0.248	0.056	0.155	0.378	0.152	0.373
Digital exploration capability → Driving- market business model innovation → transformation performance	0.195	0.041	0.127	0.286	0.120	0.279

0.286) and (0.120, 0.279) for driving-market business model innovation, and all upper and lower intervals do not contain 0, indicating that the mediating effects of both market-driven business model innovation and driving-market business model innovation exist, again proving H3a and H3b to be valid.

4.3. Fuzzy-set qualitative comparative analysis

Based on the original research model, this study combines further analysis with fsQCA to discuss how digital exploitation capability, digital exploration capability, market-driven business model innovation, and driving-market business model innovation can have synergistic effects to help SMEs achieve transformation performance. Based on general recommendations and examples from information systems management research [71], we used fsQCA to analyze complex antecedents of transformation performance using high transformation performance as an outcome variable. The analysis steps are as follows: (1) obtain fuzzy affiliation scores by calibrating the raw data; (2) conduct a necessity analysis for all antecedent variables; (3) use a truth table to determine the combination of sufficient conditions; and (4) conduct a robustness test.

4.3.1. Calibration

According to the analysis steps of the fsQCA, we calibrated the data for the five variables of digital exploitation capability, digital exploration capability, market-driven business model innovation, driving-market business model innovation, and transformation performance to determine the full membership, fully non-membership, and cross-over point, and transformed the original scale data into a continuous set of 0–1. The means of the five main constructs were calculated and the new variables generated were used as calibration thresholds, with the three thresholds corresponding to the three-member affiliations of 0.95, 0.5, and 0.05 respectively [72]. In this study, data were collected using a Likert 5-point scale, therefore, '1′ was used as a full non-membership and '5′ as a full membership. For the 0.5 splits, the mean value was used to replace this threshold of membership affiliation [73]. Finally, by setting these three thresholds, the fuzzy scores were converted to between 0 and 1 using the fsQCA 3.0 software. The specific calibration results are shown in Table 7.

4.3.2. Analysis of necessary conditions

Before performing a configuration analysis, it is necessary to test whether a single antecedent condition is necessary for the result. It is generally accepted that a condition is considered necessary to lead to an outcome when the consistency is greater than 0.9 and has a certain level of coverage [72]. As can be seen from Table 8, the consistency of all tests of the necessity of a single antecedent condition on the outcome variable is less than 0.9, and there is no condition necessary to improve transition performance. Therefore, we will further analyze the complex relationship between the role of antecedent conditions on transformation performance.

4.3.3. Analysis of sufficient conditions

In determining the raw consistency threshold and the case frequency threshold, the following premises need to be met [71,74]: (i) for samples larger than 150 cases the frequency threshold may be set at 3 (or higher); (ii) the number of observed cases should be no less than 80 % of the total; and (iii) the distribution of 0–1 in the truth table should be covered and approximately balanced. Therefore, we set the raw consistency threshold to 0.8, and the case frequency threshold to 7(containing 95 % of the cases). At the same time, we set the PRI value threshold to 0.8 [75](Waldkirch M et al., 2021), resulting in a complex, parsimonious, and intermediate solution. According to the recommendations of FISS [71], the parsimonious and intermediate solutions were used to determine the presentation of the final results of the configurations, as shown in Table 9.

This study used fsQCA 3.0 to conduct a sufficient conditions analysis to identify antecedent constructs for high transformation performance as shown in Table 9, and compared the results with those of SEM. The results show an overall solution coverage of 0.894 and an overall solution consistency of 0.875, both of which are above 0.8 and meet the analysis requirements [71]. The study identified three configurations that achieved high transformation performance, Y1, Y2, and Y3, reflecting the important characteristic of the "different paths to the same end" perspective of the configurations (see appendix 2).

The results of the fsQCA analysis show consistency with those of the SEM. Configurations Y1, Y2, and Y3 reflect the presence and absence of the combination of digital ambidextrous capabilities and business model innovation, indicating the importance of these antecedent conditions for achieving high transformation performance. The presence of both digital exploitation capability and market-driven business model innovation as core causal conditions in Group Y1 demonstrates they are two key variables in improving transformation performance. Further analysis shows that digital exploitation capability does not directly contribute to transformation performance, but has to synergize with market-driven business model innovation to achieve high transformation performance, demonstrating a positive correlation between digital exploitation capability and market-driven business model innovation. This is consistent with the test results for SEM's paths L1 and L5 and therefore supports H1a, which in turn indicates a mediating role for

Table 7
Calibration of variables.

Variables	Fuzzy value calibration		
	Full Membership	Cross-over Point	Full Non-membership
Digital exploitation capability	5	4.087	1
Digital exploration capability	5	3.084	1
Market-driven business model innovation	5	3.972	1
Driving-market business model innovation	5	3.910	1
Transformation performance	5	3.926	1

Table 8
Necessity analysis.

Antecedent conditions	High transformation performance	
	Consistency	Coverage
Digital exploitation capability	0.838933	0.827905
~Digital exploitation capability	0.508091	0.752662
Digital exploration capability	0.822984	0.806447
~Digital exploration capability	0.498101	0.745802
Market-driven business model innovation	0.858737	0.858937
~Market-driven business model innovation	0.474383	0.688893
Driving-market business model innovation	0.855934	0.862687
~Driving-market business model innovation	0.483380	0.694303

Table 9
Configuration for achieving high/non-high transformation performance.

	High transformation performance		
	Y1	Y2	Y3
Digital exploitation capability	●		
Digital exploration capability		●	
Market-driven business model innovation	●		●
Driving-market business model innovation		●	●
Raw coverage	0.774552	0.761174	0.766899
Unique coverage	0.0666587	0.0601161	0.0230763
Consistency	0.916684	0.921429	0.923071
Overall solution coverage	0.893674		
Overall solution consistency	0.875415		

Note: ● = core condition present; blank spaces = condition may be either present or absent.

market-driven business model innovation and supports H3a. The presence of both digital exploration capability and driving-market business model innovation as core causal conditions in configuration Y2 demonstrates they are two key variables in improving transformation performance. Specifically, digital exploration capability does not directly contribute to transformation performance but has to synergize with driving-market business model innovation to achieve high transformation performance, demonstrating a positive correlation between digital exploration capability and driving-market business model innovation. This is consistent with the test results of SEM's paths L2 and L6 and therefore supports hypothesis H1b, which in turn indicates the mediating role of driving-market business model innovation and supports H3b. Configuration Y3 has market-driven business model innovation and driving-market business model innovation as core causal conditions present, indicating a positive correlation between these two business model innovations on transformation performance, which is consistent with SEM's tests for paths L3 and L4, thus supporting H2a and H2b.

4.3.4. Robustness analysis

This study adopted three different approaches to analyzing the robustness of the grouping results based on previous experience with fsQCA analysis [71,72]. Firstly, the consistency threshold was increased from 0.8 to 0.85, and consistent results were obtained; secondly, the number of case frequencies was adjusted from 7 to 10, and the grouping results did not change; finally, the calibration method was changed and a direct calibration method was used, with 5 representing fully affiliated members, 1 representing fully unaffiliated members and 3 representing intersections, and similar results were obtained, with histories Y1, Y2, and Y3 being subsets of this result After the above multi-method analysis, it was proved that the grouping analysis results of this study are robust (see appendix 3).

5. Discussion and conclusion

As the academic community is currently calling attention to ambidextrous aspects of digital transformation in SMEs, we follow the research trend to analyze a new and unexplored issue. This study proposes a new model of 'capability-behavior-performance' based on the context of digital transformation in SMEs, using SEM and fsQCA to explore the relationship between digital ambidextrous capabilities, business model innovation, and transformation performance, enriching the research perspective on the dual issue of digital transformation of SMEs. According to the analysis of the results, we obtained the following research findings.

(i) Digital exploitation capability is positively associated with market-driven business model innovation, while digital exploration capability is positively associated with driving-market business model innovation. Digital exploitation capability improves efficiency and execution, implying the use of digital technologies to integrate, consolidate and optimize existing business processes and technologies, to meet existing customer needs and to improve existing market structures, and this ability to adapt to changes in existing markets to make dynamic adjustments can effectively promote market-driven business model innovation. Digital exploration capability is the ability to explore new possibilities, which can help SMEs develop new business and create new value with the help of digital technology, so that enterprises can improve their sensitivity to capture new opportunities and enter new markets in the process of transformation, satisfy the potential market demand, and become a leader in opening up new markets, so the digital exploration capability can effectively realize market-driven business model innovation.

(ii) The relationship between digital ambidextrous capabilities and transformation performance is indirect, with business model innovation playing a fully mediating role between them. Digital technology empowers companies to acquire digital ambidextrous capabilities, which can only be transformed into digital value through business model innovation, ultimately enhancing transformation performance. Digital exploitation capability can promote market-driven business model innovation, enabling companies to respond to the existing market, this conservative strategic action can bring stable cash flow for the company. And digital exploration capability can promote Driving-market business model innovation, helping companies to utilize digital technology to open up new markets and create new value. Therefore, digital ambidextrous capabilities can drive SEMs to implement transformation strategies and ultimately gain transformation performance through both types of business model innovation.

(iii) There are three ways to achieve high transformation performance, and SMEs should allocate their resources and capability base appropriately to maximize the combined effect of digital exploration capability, digital exploitation capability, market-driven business model innovation, and driving-market business model innovation. According to the findings of the fsQCA, SMEs undergoing digital transformation can take different actions to gain transformation performance depending on their resource endowments. SMEs with digital exploitation capability are essentially market-driven business model innovations by leveraging digital technologies to improve efficiency and optimize processes, which is a positive response to the existing market. SMEs with digital exploration capability are more adept at anticipating potential customer needs and making breakthrough innovations, essentially opening up future markets for driving-market business model innovation. These two approaches achieve a reasonable match between capabilities and business models, which helps companies gain transformation performance. In addition, even SMEs that lack digital ambidextrous capabilities can deliver transformation performance if they can balance the two actions of market-driven and driving-market business model innovation, which reflects a balanced and dynamic mindset that is important for the enterprise's long-term development.

5.1. Theoretical implications

Theoretically, most of the current research focuses on the positive consequences of digital transformation, such as its ability to increase organizational resilience, improve innovation performance, etc. However, some scholars have focused on the transformation paradox companies face in the process of digital transformation and have begun to call for a discussion of the complex implications of digital transformation for achieving organizational ambidexterity [32], to which this study responds positively with three main contributions. Firstly, this study fills a research gap in discussing how SMEs can improve their digital transformation performance from an ambidextrous perspective by constructing a model that includes digital exploitation capability, digital exploration capability, market-driven business model innovation, driving-market business model innovation, and transformation performance from a perspective of SMEs undergoing digital transformation [20,39]. Secondly, the full mediating role of market-oriented business model innovation between digital ambidextrous capabilities and transformation performance has not yet been found, while this study combines two methods of structural equation modeling and fuzzy set qualitative comparative analysis to verify this, and clarifies that digital exploitation capability and digital exploration capability are indirectly associated with market-driven business model innovation and driving-market business model innovation on transformation performance, respectively. This means that SMEs can effectively promote business model innovation based on market orientation in the process of building digital exploitation capability and digital exploration capability to pursue higher transformation performance, thereby maximizing the value of digital transformation. Finally, academics are divided on the implications of ambidextrous capabilities for SMEs currently, lacking of research on ambidextrous capabilities in SMEs [76]. On the one hand, some scholars point out that SMEs are constrained by their resources and capabilities and that pursuing duality is risky or even a dangerous and incorrect strategy [12], while on the other hand, some scholars point out that ambidextrous capabilities help SMEs mitigate the duality paradox and increase flexibility and agility to adapt to a dynamic and changing environment [8]. In this regards, this study confirms the positive implications of digital ambidextrous capabilities, helps to bridge the gap between existing studies and responds to the urgent call to enrich "ambidextrous capabilities research in SMEs" [77].

5.2. Managerial implications

Firstly, by building digital ambidextrous capabilities, SMEs can effectively overcome and resolve the dilemma of digital transformation, such as whether to adopt a conservative strategy of optimizing existing processes or a radical strategy of breaking through change. Digital exploitation capability enables the incorporation, integration and optimization of existing business processes and technologies with the help of digital technology to meet existing customer needs and improve existing market structures; digital exploration capability enables companies to become leaders in opening up new markets by increasing their agility in capturing new opportunities and entering new markets during the transformation process to meet potential market needs. By building digital exploitation capability and digital exploration capability, companies can effectively promote market-oriented business model innovation, thus adapting to the dynamically changing digital environment and achieving sustainable development. At the same time, according to the group analysis, digital exploration capabilities can play a synergistic role with the two business model innovations to achieve high transformation performance for SMEs. Therefore, SMEs should pay more attention to developing and enhancing their digital exploration capability during the transformation process.

Secondly, SMEs must focus on business model innovation, which can follow the logic of "digital ambidextrous capabilities-business model innovation-transformation performance". The digital transformation of SMEs must rely on business model innovation to maximize value, where digital exploitation capability can effectively drive market-driven business model innovation, but with a conservative strategy focused on competing for existing market share, while digital exploration capabilities can efficiently promote driving-market business model innovation, which is an aggressive strategy dedicated to exploring the potential needs of customers and can quickly capture new market niches, enabling rapid improvements in business performance. Therefore, in the process of digital transformation, SMEs with different capabilities value the key role of business model innovation and choose the appropriate type of business model innovation to enhance their own transformation performance.

Finally, to achieve higher transformation performance, SMEs should focus on performance improvement paths with innate advantages according to their resource and capability base. Based on the fuzzy set qualitative comparative analysis, we have identified three grouping paths to achieve high transformation performance, which not only confirms the fully mediating role played by business model innovation between digital ambidextrous capabilities and transformation performance, but also inspires SMEs experiencing transformation dilemmas to focus on the combined effect of digital exploitation capability, digital exploration capability, market-driven business model innovation, and driving-market business model innovation, which suggests strategies for SMEs with different realistic foundations to advance their digital transformation.

5.3. Limitations and future research

Our study still suffers from the following shortcomings: firstly, the scope of the selected research subjects is not comprehensive enough, and there are limitations in understanding the dilemmas faced by Chinese SMEs in their current digital transformation, and there are also differences between Chinese national conditions and those of other countries, so the findings and the scope of the study need to be further expanded and deepened; secondly, digital capabilities are deconstructed based on organizational ambidexterity theory, but the formation mechanism of digital capabilities has not been clarified, and the classification of digital capabilities is based on the traditional ambidexterity perspective, and there may be other levels of understanding and classification. Thirdly, most of the current studies on business model innovation are based on the dual model of efficiency and novelty proposed by Zott and Amit [23], and there are fewer studies from a market-oriented perspective. Therefore, the business model innovation proposed in this study has to be further supported by empirical tests or case studies.

Data availability statement

The data is not available. Data will be made available on request.

Ethics declarations

1. Review and/or approval by an ethics committee was not needed for this study because [Our study is a managerial empirical study and does not involve any ethical issues.].
2. Informed consent was not required for this study because [The data for this study was collected by questionnaire only and was informed for academic purposes and did not involve any issues requiring informed consent.].

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CRediT authorship contribution statement

Hao Jing: Writing – review & editing, Conceptualization, Formal analysis, Methodology, Resources, Supervision, Project administration. **Yaoyao Zhang:** Data curation, Investigation, Methodology, Validation, Visualization, Writing – original draft, Software. **Jia Ma:** Supervision, Conceptualization, Project administration.

Declaration of competing interest

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

Appendix

1.Questionnaire

A study of SMEs undergoing digital transformation.

Thank you for taking the time to open this questionnaire and contribute to our academic research! If your company is using digital technologies for product development, business upgrading, or process optimization, please answer the following questions according to your company's current situation.

All your answers will be kept strictly confidential and will be used for academic research purposes only. Good luck with your work and enjoy your life!

The following research is about your basic information and is for research purposes only.

1. Is your company an SME? [Multiple choice] *
   ○ Yes
   ○ No (Please skip to the end of the first questionnaire and submit your answer)
2. The company you work for is in the range of [multiple choice] *
   ○ Under 100 people
   ○ 100–500 people
   ○ 500–1000 people
   ○ 1000–3000 employees
3. The nature of the company you are working for is [multiple choice] *
   ○ State-owned
   ○ Private
   ○ Joint venture
   ○ Foreign invested
   ○ Other
4. The industry your company is in is [multiple choice] *
   ○ Internet industry (product design, platform development, new media operation, etc.)
   ○ Consumer goods industry (automotive, light industry, pharmaceuticals, etc.)
   ○ Modern service industry (wholesale and retail, logistics, education and training, catering and entertainment, etc.)
   ○ Infrastructure industry (infrastructure facilities, transportation, etc.)
   ○ Comprehensive basic industries (agriculture, trade, real estate, etc.)
   ○ Financial industries (banking, bonds, financial investment, etc.)
   ○ Energy industry (electricity, new energy, oil and gas, etc.)
   ○ Materials industry (building materials, iron and steel, non-ferrous metals, etc.)
   ○ Equipment manufacturing industries (construction machinery, artificial intelligence, electric power equipment)
   ○ Emerging industries (new energy vehicles, ecological protection, information technology, etc.)
   ○ Other industries (public welfare, etc.)
5. Age of your company is [multiple choice] *
   ○ Under 5 years
   ○ 5–10 years
   ○ 10–15 years
   ○ 15 years or more
6. Your company currently uses digital technologies such as [multiple choice] *
   ☐ Big data analytics
   ☐ Database
   ☐ cloud computing
   ☐ Artificial Intelligence
   ☐ Internet of Things
   ☐ Other digital technologies

There are 15 questions below, each of which is divided into five levels: very dissatisfied, dissatisfied, average, satisfied and very satisfied, so please judge and rate them according to the actual situation of your company.

7. Digital technology helps our company to effectively support the overall objectives of the business today[multiple choice] *
   ○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
8. Our company can effectively leverage relevant resources and drive digital transformation [multiple choice] *
   ○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
9. Our company can effectively use digital technology to optimize existing business activities [multiple choice] *
   ○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory

10. Digital technology helps our company to respond flexibly to market changes today [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
11. Our company can quickly adapt and upgrade to business changes with digital technology [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
12. Our company can use digital technology to facilitate R&D activities in response to changes in the external environment [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
13. Our company sets business goals based on market and customer needs [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
14. Our company has increased its existing market share in the course of digital transformation [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
15. Our company has improved the efficiency of existing transactions in the course of digital transformation [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
16. Our company is able to constantly explore and explore the potential needs of the market and our customers [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory*
17. Our company is committed to opening up and capturing new markets in the process of digital transformation[multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
18. Our company creates new trading relationships by developing new products [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
19. Higher sales growth for our company than before the digital transformation [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
20. Higher market share growth for our company than before the digital transformation [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory
21. Higher profit growth for our company than before the digital transformation [multiple choice] *
○ Very unsatisfactory ○Unsatisfactory ○General ○Satisfactory ○Very satisfactory

2. Truth table(High configuration)

(L5-digital exploitation capability; T5-digital exploration capability; S5-market-driven business model innovation; Q5-driving-market business model innovation; Z5-Transformantion performance).

File Edit

L5	T5	S5	Q5	number	Z5	raw consist.	PRI consist.	SYM consist
1	1	1	1	67 (23%)		0.96385	0.924102	0.946477
0	0	0	0	40 (37%)		0.783645	0.199046	0.2006
0	0	1	1	31 (47%)		0.943958	0.729231	0.734884
1	0	1	0	19 (54%)		0.945351	0.757844	0.768327
0	1	0	0	15 (59%)		0.849984	0.357633	0.358126
0	1	1	1	15 (64%)		0.969344	0.870457	0.880261
0	0	0	1	14 (69%)		0.924352	0.560449	0.562755
0	0	1	0	13 (74%)		0.94128	0.639699	0.639699
1	0	1	1	13 (78%)		0.947523	0.79476	0.814318
1	0	0	0	10 (82%)		0.876854	0.378048	0.378048
1	1	1	0	10 (85%)		0.943365	0.754808	0.766321
0	1	0	1	10 (88%)		0.941871	0.722138	0.727
1	1	0	1	10 (92%)		0.945338	0.772384	0.776874
1	0	0	1	8 (95%)		0.92332	0.584683	0.596506
1	1	0	0	7 (97%)		0.864784	0.44819	0.448191
0	1	1	0	7 (100%)		0.935567	0.642858	0.642858

****
TRUTH TABLE ANALYSIS
****
Model: Z5 = f(L5, T5, S5, Q5)

Algorithm: Quine-McCluskey.
— COMPLEX SOLUTION —
frequency cutoff: 7
consistency cutoff: 0.941871
raw unique
coverage coverage consistency.
———————— ———————— ————————

L5*S5 0.774552 0.0666587 0.916684.
T5*Q5 0.761174 0.0601161 0.921429.
S5*Q5 0.766899 0.0230763 0.923071
solution coverage: 0.893674
solution consistency: 0.875415.
— PARSIMONIOUS SOLUTION —
frequency cutoff: 7
consistency cutoff: 0.941871
raw unique
coverage coverage consistency.
———————— ———————— ————————

L5*S5 0.774552 0.0666587 0.916684.
T5*Q5 0.761174 0.0601161 0.921429.
S5*Q5 0.766899 0.0230763 0.923071
solution coverage: 0.893674
solution consistency: 0.875415.
— INTERMEDIATE SOLUTION —
frequency cutoff: 7
consistency cutoff: 0.941871.
Assumptions:
raw unique
coverage coverage consistency.
———————— ———————— ————————

L5*S5 0.774552 0.0666587 0.916684.
T5*Q5 0.761174 0.0601161 0.921429.
S5*Q5 0.766899 0.0230763 0.923071
solution coverage: 0.893674
solution consistency: 0.875415.

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L5	T5	S5	Q5	number	Z5	raw consist.	PRI consist.	SYM consist
1	1	1	1	67 (23%)		0.96385	0.924102	0.946477
0	0	0	0	40 (37%)		0.783645	0.199046	0.2006
0	0	1	1	31 (47%)		0.943958	0.729231	0.734884
1	0	1	0	19 (54%)		0.945351	0.757844	0.768327
0	1	0	0	15 (59%)		0.849984	0.357633	0.358126
0	1	1	1	15 (64%)		0.969344	0.870457	0.880261
0	0	0	1	14 (69%)		0.924352	0.560449	0.562755
0	0	1	0	13 (74%)		0.94128	0.639699	0.639699
1	0	1	1	13 (78%)		0.947523	0.79476	0.814318
1	0	0	0	10 (82%)		0.876854	0.378048	0.378048
1	1	1	0	10 (85%)		0.943365	0.754808	0.766321
0	1	0	1	10 (88%)		0.941871	0.722138	0.727
1	1	0	1	10 (92%)		0.945338	0.772384	0.776874
1	0	0	1	8 (95%)		0.92332	0.584683	0.596506
1	1	0	0	7 (97%)		0.864784	0.44819	0.448191
0	1	1	0	7 (100%)		0.935567	0.642858	0.642858

3. Robustness analysis

Group 1————changing consistency level.
Group 2————changing threshold of case number.
Group 3————changing calibration.

	1			2			3			
	1a	1b	1c	2a	2b	2c	3a	3b	3c	3d
Digital exploitation capability	●			●			●	●	●	
Digital exploration capability		●			●		●	●		●
Market-driven business model innovation	●		●	●		●	●		●	●
Driving-market business model innovation		●	●		●	●		●	●	●
Raw coverage	0.775	0.761	0.767	0.775	0.761	0.767	0.841	0.835	0.840	0.831
Unique coverage	0.067	0.601	0.023	0.067	0.060	0.023	0.034	0.028	0.033	0.025
Consistency	0.917	0.921	0.923	0.915	0.921	0.923	0.954	0.956	0.960	0.965
Overall solution coverage	0.894			0.894			0.927			
Overall solution consistency	0.875			0.875			0.931			

References

[1] G. Elia, A. Margherita, G. Passiante, Digital entrepreneurship ecosystem: how digital technologies and collective intelligence are reshaping the entrepreneurial process, Technol. Forecast. Soc. Change 150 (1) (2020), 119791, https://doi.org/10.1016/j.techfore.2019.119791.
[2] D. Ulas, Digital transformation process and SMEs, Procedia Comput. Sci. 158 (2019) 662–671.
[3] A. Annarelli, C. Battistella, F. Nonino, et al., Literature review on digitalization capabilities: co-citation analysis of antecedents, conceptualization and consequences, Technol. Forecast. Soc. Change 166 (3) (2021), 120635, https://doi.org/10.1016/j.techfore.2021.120635.
[4] G. Vial, Understanding digital transformation: a review and a research agenda, J. Strat. Inf. Syst. 28 (2) (2019) 118–144.
[5] L. Gastaldi, F.P. Appio, M. Corso, et al., Managing the exploration-exploitation paradox in healthcare, Business Process Management 24 (5) (2018) 1200–1234.
[6] Y. Lu, X. Xu, L. Wang, Smart manufacturing process and system automation -A critical review of the standards and envisioned scenarios, J. Manuf. Syst. 56 (2020) 312–325.
[7] J.H. Shin, H.B. Jun, On condition based maintenance policy, Journal of Computational Design & Engineering 2 (2) (2015) 119–127.
[8] L. Gastaldi, S. Lessanibahri, G. Tedaldi, et al., Companies' adoption of smart technologies to achieve structural ambidexterity: an analysis with SEM. Technological Forecasting and Social Change, Technol. Forecast. Soc. Change 174 (C) (2022), 121187, https://doi.org/10.1016/j.techfore.2021.121187.
[9] J.G. March, Exploration and exploitation in organizational learning, Organ. Sci. 2 (1) (1991) 71–87.
[10] J. Hafkesbrink, M. Schroll, Ambidextrous organizational and individual competencies in oi: the dawn of a new research agenda, World Scientific Book Chapters 21 (1) (2016) 9–46.
[11] C.A. O'Reilly, M.L. Tushman, Organizational ambidexterity: past , present , and future, Acad. Manag. Perspect. 27 (4) (2013) 324–338.
[12] G.B. Voss, Z.G. Voss, Strategic ambidexterity in small and medium-sized enterprises: implementing exploration and exploitation in product and market domains, Organ. Sci. 24 (5) (2013) 1459–1477.
[13] J. Birkinshaw, K. Gupta, Clarifying the distinctive contribution of ambidexterity to the field of organization studies, Acad. Manag. Perspect. 27 (4) (2013) 287–298.
[14] R.V.D. Wetering, The role of enterprise architecture-driven dynamic capabilities and operational digital ambidexterity in driving business value under the COVID-19 shock, Heliyon 8 (11) (2022), e11484, https://doi.org/10.1016/j.heliyon.2022.e11484.
[15] W. Coreynen, P. Matthyssens, J. Vanderstraeten, et al., Unravelling the internal and external drivers of digital servitization: a dynamic capabilities and contingency perspective on firm strategy, Ind. Market. Manag. 89 (2020) 265–277.
[16] C.A. O'Reilly, M.L. Tushman, Ambidexterity as a dynamic capability: resolving the innovator's dilemma, Res. Organ. Behav. 28 (2008) 185–206.
[17] A. Chaudhuri, N. Subramanian, M. Dora, Circular economy and digital capabilities of SMEs for providing value to customers: combined resource-based view and ambidexterity perspective, J. Bus. Res. 142 (1) (2022) 32–44.
[18] J.A. Felício, V. Caldeirinha, A. Dutra, Ambidextrous capacity in small and medium-sized enterprises, J. Bus. Res. 101 (1) (2019) 607–614.
[19] J. Zhen, Z. Xie, K. Dong, Impact of IT governance mechanisms on organizational agility and the role of top management support and it ambidexterity, Int. J. Account. Inf. Syst. 40 (2) (2021), 100501, https://doi.org/10.1016/j.accinf.2021.100501.
[20] F. Alberto, M. Filippo, M. Jens, Ambidextrous IT capabilities and business process performance: an empirical analysis, Bus. Process Manag. J. 24 (1) (2018) 1077–1090.
[21] C. Loebbecke, A. Picot, Reflections on societal and business model transformation arising from digitization and big data analytics: a research agenda, J. Strat. Inf. Syst. 24 (3) (2015) 149–157.
[22] T. Ritter, C.L. Pedersen, Digitization capability and the digitalization of business models in business-to-business firms: past, present, and future, Ind. Market. Manag. 86 (4) (2020) 180–190.
[23] C. Zott, R. Amit, Business model innovation: how to create value in a digital world, GfK Mark. Intell. Rev. 9 (1) (2017) 18–23.
[24] M. Kohtamäki, V. Parida, P. Oghazi, et al., Digital servitization business models in ecosystems: a theory of the firm, J. Bus. Res. 104 (2019) 380–392.
[25] H. Ma, X.L. Jia, X. Wang, Digital Transformation, Ambidextrous innovation and enterprise value: empirical analysis based on listed Chinese manufacturing companies, Sustainability 14 (15) (2022) 1–20.
[26] B. Jaworski, A. Kohli, A. Sahay, Market-driven versus driving markets, J. Acad. Market. Sci. 28 (1) (2000) 45–54.
[27] D. Herhausen, Unfolding the ambidextrous effects of proactive and responsive market orientation, J. Bus. Res. 69 (7) (2016) 2585–2593.
[28] N. Kumar, L. Scheer, P. Kotler, From market driven to market driving, Eur. Manag. J. 18 (2) (2000) 129–142.
[29] H. Bouwman, S. Nikou, M.D. Reuver, E. Bohlin, Digitalization, business models, and SMEs: how do business model innovation practices improve performance of digitalizing SMEs? Telecommun. Pol. 43 (9) (2019), 101828.

[30] S. Khin, T.C. Ho, Digital technology, digital capability and organizational performance: a mediating role of digital innovation, Int. J. Innovat. Sci. 11 (6) (2018), 231834, https://doi.org/10.1108/IJIS-08-2018-0083.
[31] C. Zott, R. Amit, L. Massa, The business model: recent developments and future research, J. Manag. 37 (4) (2011) 1019–1042.
[32] Y.K. Park, P.A. Pavlou, N. Saraf, Configurations for achieving organizational ambidexterity with digitization, Inf. Syst. Res. 31 (4) (2020) 1–22.
[33] M.D. Giudice, V. Scuotto, A. Papa, et al., A self-tuning model for smart manufacturing SMEs: effects on digital innovation, J. Prod. Innovat. Manag. 38 (1) (2020) 68–89.
[34] J.A. Felício, V. Caldeirinha, A. Dutra, Ambidextrous capacity in small and medium-sized enterprises, J. Bus. Res. 101 (1) (2019) 607–614.
[36] J. Heredia, M. Castillo-Vergara, C. Geldes, et al., How do digital capabilities affect firm performance? The mediating role of technological capabilities in the "new normal", Journal of Innovation & Knowledge 7 (2) (2022), 100171, https://doi.org/10.1016/j.jik.2022.100171.
[37] R. Mostaghel, P. Oghazi, V. Parida, et al., Digitalization driven retail business model innovation: evaluation of past and avenues for future research trends, J. Bus. Res. 146 (2022) 134–145.
[38] M. Kohtamäki, V. Parida, P. Oghazi, et al., Digital servitization business models in ecosystems: a theory of the firm, J. Bus. Res. 104 (2019) 380–392.
[39] K. Randhawa, R. Wilden, S. Gudergan, How to innovate toward an ambidextrous business model? The role of dynamic capabilities and market orientation, J. Bus. Res. 130 (1) (2021) 618–634.
[40] S. Liao, Z. Liu, S. Zhang, Technology innovation ambidexterity, business model ambidexterity, and firm performance in Chinese high-tech firms, Asian J. Technol. Innovat. 26 (3) (2018) 325–345.
[41] M.A. Mahmoud, N. Owusu-Frimpong, T.P. Trang, et al., Market orientation, learning orientation and business performance: the mediating role of innovation, Int. J. Bank Market. 34 (5) (2016) 623–648.
[42] V. Minatogawa, M. Franco, O. Durán, et al., Carving out new business models in a small company through contextual ambidexterity: the case of a sustainable company, Sustainability 12 (6) (2020) 2337, https://doi.org/10.3390/su12062337.
[43] T. Huikkola, M. Kohtamaki, J. Ylimaki, Becoming a smart solution provider: reconfiguring a product manufacturer's strategic capabilities and processes to facilitate business model innovation, Technovation 118 (10) (2022), 102498, https://doi.org/10.1016/j.technovation.2022.102498.
[44] J. Gao, W. Zhang, T. Guan, Q. Feng, et al., The effect of manufacturing agent heterogeneity on enterprise innovation performance and competitive advantage in the era of digital transformation, J. Bus. Res. 155 (2023), 113387, https://doi.org/10.1016/j.jbusres.2022.113387.
[45] A.G. Frank, G. Mendes, N.F. Ayala, et al., Servitization and industry 4.0 convergence in the digital transformation of product firms: a business model innovation perspective, Technol. Forecast. Soc. Change 14 (C) (2019) 341–351.
[46] T. Hess, C. Matt, A. Benlian, Options for formulating a digital transformation strategy, MIS Q. Exec. 15 (2) (2016) 123–139.
[47] Q. Chen, Z. Liu, How does TMT transactive memory system drive innovation ambidexterity?: shared leadership as mediator and team goal orientations as moderators, Chin. Manag. Stud. 12 (1) (2018) 125–147.
[48] F. Blindenbach-Driessen, J.V. Ende, The Locus of Innovation: the Effect of a separate innovation unit on exploration, exploitation, and ambidexterity in manufacturing and service firms, J. Prod. Innovat. Manag. 31 (5) (2014) 1089–1105.
[49] S. Nambisan, K. Lyytinen, Y. Yoo, Handbook of Digital Innovation, Edward Elgar Publishing, 2020.
[50] T.A. Fischer, H. Gebauer, M. Gregory, et al., Exploitation or exploration in service business development? : insights from a dynamic capabilities perspective, J. Serv. Manag. 21 (5) (2010) 591–624.
[51] T.Y. Tang, S.K. Zhang, J. Peng, The value of marketing innovation: market-driven versus market-driving, J. Bus. Res. 126 (2021) 88–98.
[52] J.C. Narver, S.F. Slater, D.L. MacLachlan, Responsive and proactive market orientation and new product success, J. Prod. Innovat. Manag. 21 (5) (2004) 334–347.
[53] S. Lee, S. Trimi, Convergence innovation in the digital age and in the covid-19 pandemic crisis, J. Bus. Res. 123 (2021) 14–22.
[54] P.F. Borowski, Digitization, digital twins, blockchain, and industry 4.0 as elements of management process in enterprises in the energy sector, Energies 14 (7) (2021) 1–20.
[55] W.T. Yu, R. Ramanathan, P. Nath, The impacts of marketing and operations capabilities on financial performance in the UK retail sector: a resource-based perspective, Ind. Market. Manag. 43 (1) (2014) 25–31.
[56] M. Rachinger, R. Rauter, C. Müller, et al., Digitalization and its influence on business model innovation, J. Manuf. Technol. Manag. 30 (2019) 1143–1160.
[57] P.F. Borowski, Digitization, digital twins, blockchain, and industry 4.0 as elements of management process in enterprises in the energy sector, Energies 14 (7) (2021) 1–20.
[58] D. Herhausen, Unfolding the ambidextrous effects of proactive and responsive market orientation, J. Bus. Res. 69 (7) (2016) 2585–2593.
[59] F. Wu, H. Hu, H. Lin, et al., Enterprise digital transformation and capital market performance: empirical evidence from stock liquidity, Manag. World 37 (7) (2016) 130–144+10.
[60] M. Chi, D. Ye, J. Wang, et al., How can Chinese Small- and Medium-sized manufacturing enterprises improve the new product development (NPD) performance? from the perspective of digital empowerment, Nankai Management Review 23 (3) (2020) 63–75.
[61] Y. Zheng, Y. Sun, J. Yin, Intelligent transformation, intelligent capability and manufacturing enterprise transformation performance: the moderating effects of strategic alignment, Science and Technology Progress and Countermeasures 39 (18) (2022) 99–109.
[62] J. Cenamor, V. Parida, J. Wincent, How entrepreneurial SMEs compete through digital platforms: the roles of digital platform capability, network capability and ambidexterity, J. Bus. Res. 100 (C) (2019) 196–206.
[63] P.M. Podsakoff, D.W. Organ, Self-reports in organizational research: problems and prospects, J. Manag. 12 (4) (1986) 531–544.
[64] S.D. Silvey, Multicollinearity and imprecise estimation, J. Roy. Stat. Soc. 31 (3) (1969) 539–552.
[65] J.C. Nunnally, I. Bernstein, Companies Create the Dynamics of Innovation, Oxford University, New York, 1994.
[66] B.A. Cerny, H.F. Kaiser, A study of A measure of sampling adequacy for factor-analytic correlation matrices, Multivariate Behav. Res. 12 (1) (1977) 43–47.
[67] J. Henseler, F. Schuberth, Using confirmatory composite analysis to assess emergent variables in business research, J. Bus. Res. 120 (c) (2020) 147–156.
[68] C. Fornell, D.F. Larcker, Structural equation models with unobservable variables and measurement error: algebra and statistics, J. Market. Res. 18 (3) (1981) 382–388.
[69] G.J. Medsker, L.J. Williams, P.J. Holahan, A review of current practices for evaluating causal models in organizational behavior and human resources management research, J. Manag. 20 (2) (1994) 439–464.
[70] D. MacKinnon, Introduction to Statistical Mediation Analysis, Routledge, New York, 2008.
[71] P.C. Fiss, Building better causal theories: a fuzzy set approach to typologies in organization research, Acad. Manag. J. 54 (2) (2011) 393–420.
[72] C.C. Ragin, Redesigning Social Inquiry: Fuzzy Sets and beyond, University of Chicago, Chicago, 2008.
[73] R.G. Bell, I. Filatotchev, R.V. Aguilera, Corporate governance and investors' perceptions of foreign IPO value: an institutional perspective, Acad. Manag. J. 57 (1) (2014) 301–320.
[74] I.O. Pappas, A.G. Woodside, Fuzzy-set qualitative comparative analysis (fsQCA): guidelines for research practice in information systems and marketing, Int. J. Inf. Manag. 58 (2021), 102310, https://doi.org/10.1016/j.ijinfomgt.2021.102310.
[75] M. Waldkirch, N. Kammerlander, C. Wiedeler, Configurations for corporate venture innovation: investigating the role of the dominant coalition, J. Bus. Ventur. 35 (5) (2021), 106137.
[76] C. Andriopoulos, M.W. Lewis, Exploitation–exploration tensions and organizational ambidexterity: managing paradoxes of innovation, Organ. Sci. 20 (4) (2009) 696–717.
[77] C. Senaratne, C.L. Wang, Organisational ambidexterity in UK high-tech SMEs: an exploratory study of key drivers and barriers, J. Small Bus. Enterprise Dev. 25 (6) (2018) 1025–1050.