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RESEARCH ARTICLE

The Impact of ERP Assimilation on Mass Customization Capability: A Dynamic Capabilities View

LIU ZONGYUAN AND HUO HAIYAN
Azman Hashim International Business School, Universiti Teknologi Malaysia, Kuala Lumpur 54100, Malaysia
Corresponding author: Huo Haiyan (haiyan.huo@graduate.utm.my)

ABSTRACT Mass customization (MC) is a crucial strategy for manufacturers to gain competitive advantages. Enterprise resource planning (ERP) systems are widely adopted in manufacturing. This study applied the dynamic capabilities view (DCV) to explore how firms leverage ERP systems to facilitate the implementation of MC. This study examined the effect of ERP assimilation (ERPA) and organizational agility (OA) on mass customization capability (MCC), the mediating role of OA, and the moderating role of absorptive capacity (AC). Data were collected using a self-administered questionnaire survey that yielded 166 responses in Jiangsu province, China. The partial least square structural equation modelling (PLS-SEM) approach was employed to test the study hypotheses. Results revealed that ERPA affects OA, and OA also affects MCC. However, no significant relationship was found between ERPA and MCC. Again, data supported the mediating effect of OA between ERPA and MCC and the moderating effect of AC between ERPA and OA.

INDEX TERMS Absorptive capacity, ERP assimilation, mass customization capability, organizational agility.

I. INTRODUCTION

Given the rising trend of personalized consumer preferences in the highly competitive market, many businesses are contemplating mass customization (MC) as a novel production strategy to bolster their competitive edge [1]. Mass customization capability (MCC) refers to "the capability to produce a wide range of customizable product options in significant quantities for a large or niche market while maintaining cost-effectiveness, prompt delivery, and high quality [2]." MC combines the benefits of precision in single-piece production with the speed and cost-effectiveness of mass production. The adoption of this strategy holds significant appeal for customers. Still, it presents a substantial obstacle for a firm and poses a potential risk of failure, mainly due to the rise in design and manufacturing expenditures [3]. Task complexities are heightened in the MC environment. Because of differentiated customer requirements, an expanded range of products, and greater inter-dependency across the supply chain. Consequently, the level of uncertainty regarding tasks increases, as does the volume of information that must be processed [4]. To effectively and efficiently implement MC under such circumstances, a firm must enhance its information processing capabilities to accommodate the increased demands [5].

Enterprise resource planning (ERP) systems have been proposed to address the complexities associated with MC [6]. ERP refers to a set of systems a business employs to oversee its financial operations and fundamental business functions [7]. ERP systems, which can be quickly adjusted, allow the development of flexible production with high productivity, low cost, and large varieties. That meets the requirements of MC [8]. However, Hong et al. [9] have tested the relationship between various information technologies (IT) usage and MCC. They found no significant relationship between the usage of ERP systems and MCC. Thus, Peng et al. [4] suggested that future studies should apply measurements that effectively reflect the degree of IT

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usage and investigate related theories and constructs in the field of MC.

In response to them, this study applies ERP assimilation (ERPA) to measure the extent to which firms use ERP systems in MC. Because ERPA provides a more accurate gauge of post-adoption success than mere implementation [10], it is defined as "the extent ERP technology is diffused in routine business processes and the degree to which it supports business decision-making at operational and strategic levels [11]. " ERPA is an ongoing and extended process, and the full benefits of ERP applications can only be realized through thorough integration into the organization [12], [13]. Notwithstanding the acknowledged necessity to facilitate ERPA, many firms cannot fulfil this requirement [14]. In China, despite firms successfully adopting ERP, many struggle with assimilating the system, preventing them from realizing its full range of advantages [10]. A previous study ascertained that high MC performers employ ERP systems more extensively than low MC performers in daily business activities management [9]. Therefore, this study proposes that a high level of ERPA can facilitate MCC for firms.

A prior study posited that firms must harness the full potential of ERP systems to realize their value, necessitating the cultivation of corresponding organizational capabilities [15]. Therefore, this study postulates that ERP may exert its influence on MCC through the mediation of other organizational capabilities. MC strategies strive to provide personalized products tailored to individual customers' needs while minimizing the reduction in production efficiency. Achieving this balance requires high organizational agility (OA) [16], [17], [18]. OA signifies a firm's capability to swiftly and effectively adapt and change in response to evolving circumstances [19]. Empirical evidence has demonstrated a positive correlation between ERPA and OA [20], [21]. Numerous scholars recognize OA as a vital factor that fosters MCC [22], [23]. Thus, this study proposes that there is a high possibility that a mediating effect of OA between ERPA and MCC may exist.

Aburub [24] posited that establishing agility via ERP systems may be contingent upon additional variables. Therefore, future studies should investigate how IT-based assimilation improves OA [25]. Assimilation of complex technology is a process of mutual adaptation between technology and mainstream business process, institutional structure, and knowledge, which requires firms to improve their absorptive capacity (AC) [26]. AC is "a firm's ability to recognize the value of new information, assimilate it, and apply it to commercial ends [27]." However, the IT-OA relationship continues to face challenges regarding the significance of AC [28]. As an organizational capability, AC can potentially affect ERPA and its relationship with OA. AC is positively related to ERPA, but differential investment in resources results in varying levels of AC among firms. Those with low AC often struggle with ERPA, leading to adverse financial and operational consequences [29]. Firms will also fail to obtain OA if AC is lacking. Thus, this study proposes the possibility of a moderating effect of AC that strengthens or weakens the relationship between ERPA and OA.

This study explores the connection between AC, ERPA, OA, and MCC in manufacturing firms in Jiangsu province, China. This study addresses four main research questions:

1. Does ERPA affect MCC?
2. Does ERPA affect OA?
3. Does OA affect MCC?
4. Does OA mediate the relationship between ERPA and MCC?
5. Does AC affect the relationship between ERPA and OA?

The rest of this study discusses the literature and hypothesis development, followed by methodology, analysis, and findings. Then, a discussion will further explain the findings. Finally, the rest presents theoretical and managerial implications, limitations, and future research directions.

II. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

A. THEORETICAL BACKGROUND

The dynamic capabilities view (DCV) provides a theoretical lens to investigate the relationship between enterprise systems and OA. Dynamic capabilities (DCs) refer to "the firm's ability to integrate, build, and reconfigure internal and external resources/competencies to address and shape rapidly changing business environments [30]." DCs have been conceptualized as a set of capabilities, including sensing, seizing, and reconfiguring [31]. Sensing capability refers to "identify, develop, co-develop, and assess technological opportunities based on customer needs." Seizing capability refers to "mobilize resources to tackle needs and opportunities and to capture value from these actions." Transforming refers to "recombining and modifying existing resources." Previous studies highlight that OA is a pivotal DC for organizations to secure lasting competitive advantages and survival in dynamic environments [32]. OA refers to a firm's ability to sense environmental change and respond readily [33]. Hence, OA comprises two elements: sensing and responding. Sensing refers to an organizational ability to quickly detect, interpret, and capture organizational opportunities. Responding represents an organizational ability to mobilize and transform resources to react to the opportunities it senses [34]. Since agility includes the capabilities to sense and respond, DCs provide a suitable framework for characterizing OA.

Theoretically, many scholars consider DCs to be hierarchical [35]. Organizations cultivate agility as a form of high-level DCs by establishing suitable work routines and harnessing lower-level DCs, such as IT utilization. Agility enables them to improve, align, and adapt their core operational capabilities [36]. ERPA is the extent to which firms use ERP systems, representing lower-level DCs in this study. According to the hierarchy of DCs, ERPA will facilitate high-level DCs, namely OA. Meanwhile, the effective implementation of MC also requires cultivating DCs [37]. OA enabled by ERPA will

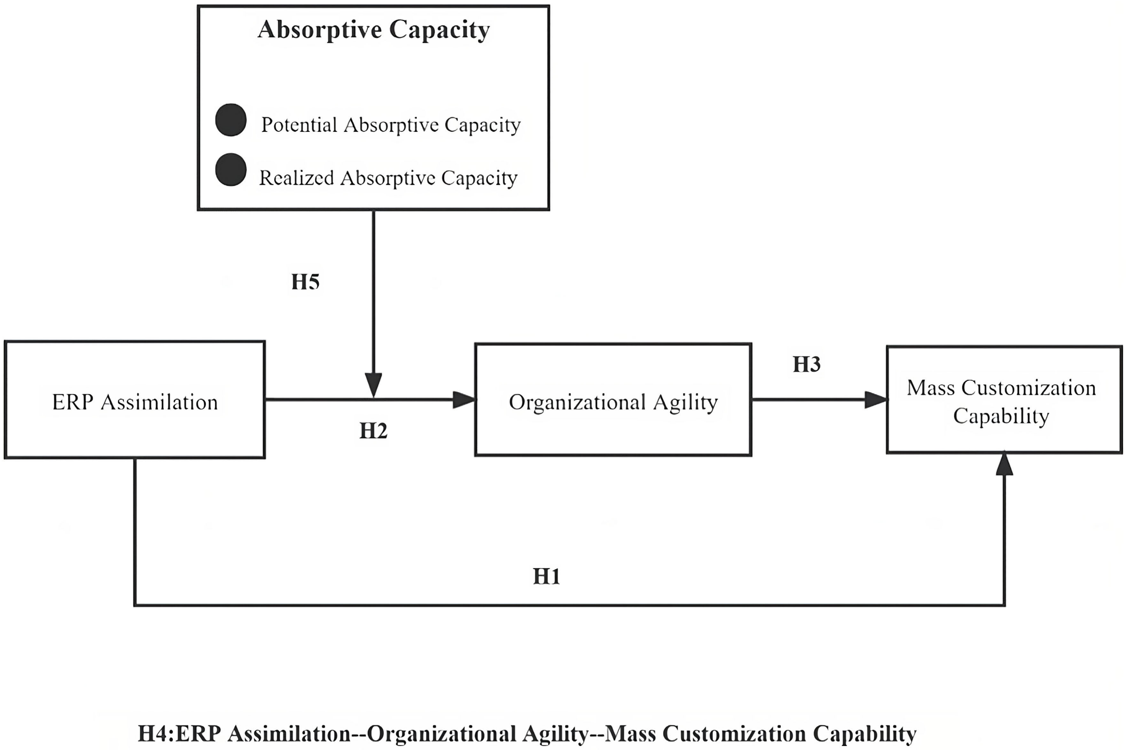

FIGURE 1. Concept framework.

promote MCC in the firm. Therefore, OA could mediate the ERPA-MCC relationship.

Additionally, OA is constructed upon the foundation of AC. AC refers to a set of organizational routines and processes by which firms systematically acquire, assimilate, transform, and exploit knowledge, producing a dynamic organizational capability [38]. It assists firms in navigating environmental uncertainties and shaping their approach to handling them. Furthermore, it influences how organizations respond [28]. In the ERP context, AC is conceptualized as a combination of potential absorptive capacity (PAC) and realized absorptive capacity (RAC) [39], [40]. PAC and RAC are both independent and complementary. Suppose organizations have no PAC to identify and acquire external technology and knowledge. In that case, no resource can be converted and utilized in the RAC. In addition, even if organizations have the PAC, they may not have the RAC; that is, they cannot transform and apply external resources [38].

From the perspective of ERP, PAC denotes an organization's ability to acquire and internalize external knowledge specifically related to the ERP system. PAC includes knowledge obtained from internal and external sources, focusing on system-specific features. RAC pertains to the organization's capability to effectively utilize ERP systems, maximizing their advantages [40]. In this study, AC is about how firms learn and apply ERP knowledge to gain the ERP system's value. In the field of ERP study, previous studies found that AC can positively affect ERPA [40], [41], [42], [43]. Therefore, to take full advantage of the functionality provided by ERP systems to drive OA, it depends on the level of the firm's AC to acquire, assimilate, transform, and exploit ERP knowledge. Fig. 1 presents the research framework.

B. POPULARITY OF ERP SYSTEM IN CHINA

ERP is integrated cross-functional software that re-engineers a firm's manufacturing, distribution, finance, human resources, and other basic business processes to improve its efficiency, agility, and profitability [44]. The Chinese government has implemented a sequence of policies to stimulate the adoption of ERP and other industrial software within the manufacturing sector to attain informatization [45]. Although large state-owned and private firms are the primary users of ERP, more small and medium enterprises (SMEs) are adopting ERP systems as they undergo digital transformation [46]. According to a report from a Chinese consulting firm, the utilization of ERP systems is relatively prevalent across various sizes of firms. In 2019, firms with 100-499 employees accounted for 37% of ERP applications, while those with 500-999 employees accounted for 11%, and those with over 1000 employees accounted for 33%. The manufacturing sector dominated the market, with a market share of over 40% [47].

C. FACILITATING ROLE OF ERP SYSTEM IN MCC

MC has risen as a significant manufacturing strategy, gaining importance with a focus on shifts in demand and technology advancements [48]. MC is a system that employs IT,

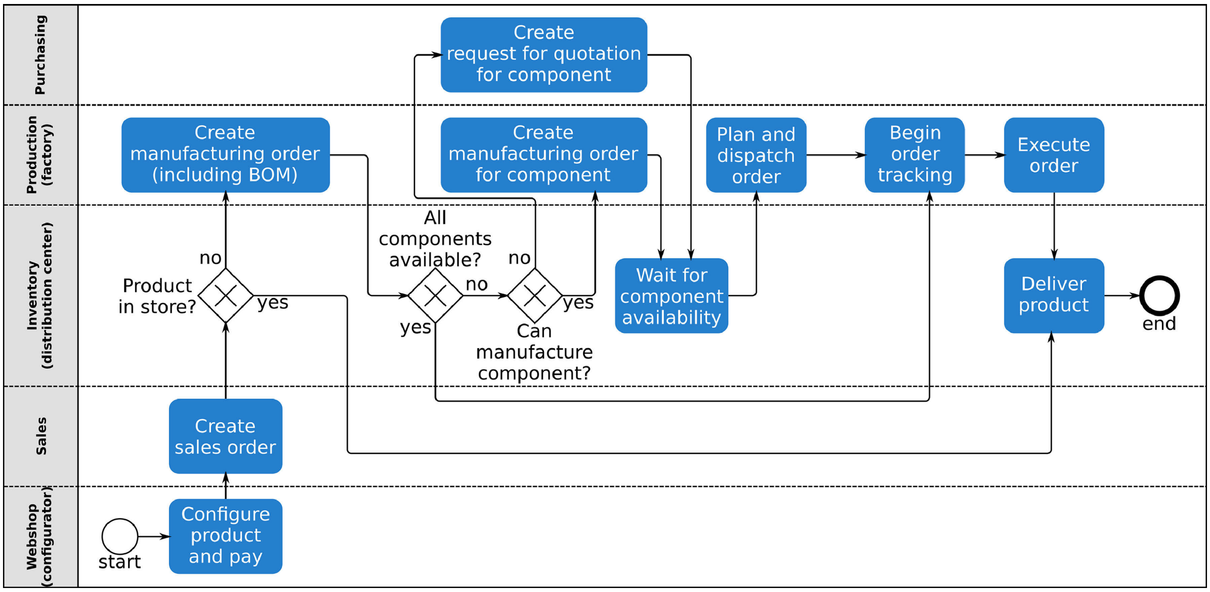

FIGURE 2. Order execution workflow for mass customization in the ERP system.

flexible processes, and organizational structures to provide diverse products and services tailored to individual customer requirements while maintaining costs close to those of mass-produced items [49]. Firms have benefited greatly from implementing MC concerning improvements in customer value, customer satisfaction, operational performance, product innovation, and firm performance [50]. The identification of factors such as the development of the product platform, product modularity, IT-based product configuration, parts standardization, group technology, process modularity, and the simultaneous product-process-supply chain integration has been acknowledged as crucial determinants for the successful implementation of MC [51].

The implementation of MC entails a complex process involving transforming consumer-specific requirements into corresponding products. This process requires coordination across various aspects, such as product configuration, manufacturing, and supply chain management. This intricate procedure necessitates handling vast amounts of data [52]. However, in practical applications, customer orders frequently exhibit high variety coupled with low volume, generating substantial data. Firms are confronted with the imperative of concurrently managing diverse orders, necessitating the deployment of efficient enterprise systems for data management [53].

A McKinsey study has highlighted that to attain profitable MC, firms must enhance their IT infrastructure, which includes investments in data warehousing and data analytics, alongside upgrading ERP and legacy systems [54]. The attributes of ERP, such as instantaneous data analysis and dissemination, and the system's capacity for internal and external integration collectively contribute to the advancement of MCC [55]. The study from [56] experimentally simulated the process of handling MC orders within an ERP system. As depicted in Fig. 2, integrating sales, manufacturing, purchase, and inventory modules in the ERP system allows for the seamless conversion of sales orders into manufacturing orders upon confirmation. Similarly, the automatic generation of manufacturing orders or requests for quotations for missing materials is evident. Customization details in sales orders are reflected in the manufacturing order's bill of materials (BOM). Throughout order execution, workstations receive precise instructions from the manufacturing module and report the completion of each manufacturing step. Integrating IT and operational technology ensures the production of correct variants, and individual order tracking facilitates the timely delivery of the finished product to customers. As shown in Table 1, the findings of previous studies [9], [55], [57], [58], [59], [60], [61], [62] indicated that adopting ERP systems can effectively support the practical advancement of MC within firms from different industries. Firms should extensively use ERP systems to develop MCC. Thus, this study proposed the following hypothesis:

H1: A high level of ERPA can positively affect MCC.

D. MEDIATING ROLE OF OA

ERP system facilitates the seamless dissemination of information across the organization, resulting in a well-informed, expeditious, efficacious, and streamlined decision-making process. The system's unified database empowers the processing, analysis, prediction, extraction, and comprehension of pertinent task-related data, thereby assisting organizations in attaining agility [63]. As shown in Table 2, several studies [20], [21], [24], [63], [64], [65], [66] have established a favorable correlation between ERP systems and agility, as assessed by different measurements in various industries. A prior study affirms that OA forms the bedrock of MCC [67]. Agility enhances the operational efficacy of the MC

TABLE 1. Application of ERP system in MC.

Author	Type of Study	Industry	Related findings
Hong et al. [9]	Empirical	General Manufacturing	Best practices within lean principles, e-commerce, e-procurement, and ERP are evident within the cohort of high-performing MC practitioners
Verdouw [57]	Case study	Agriculture	Adoption of configurators in ERP system combined product and process configuration that support MC
Wang et al. [58]	Case study	Automobile	Application of manufacturing-oriented product information model in ERP system that can support MC
Yeung and Choi [59]	Empirical	Apparel	Adoption of a supply chain management module of the ERP system with the external EDI platform contributes to the successful implementation of MC
Xiong et al. [60]	Conceptual	Furniture	ERP, as a comprehensive management system, can support the implementation of mass customization
Grobler-Dębska et al. [61]	Case study	Furniture	Adoption of a demand forecasting module of an ERP system can predict the needs of intermediate goods in mass customization
Zhang et al. [55]	Case study	Housing	Integrating the ERP system with its subsystem optimizes information utilization in design and production, enhancing both manufacturing flexibility and lean production capacity, contributing to the effective implementation of mass customization
Dudek et al. [62]	Case study	Textile	Adoption of a new algorithm using knowledge and data from the ERP system aims to simulate scenarios for generating client orders that improve mass customization

production model. This enables firms to augment adaptability, promptness, and proficiency in addressing the diverse requirements of their clients, thereby minimizing instances of disruption [68]. A case from McKinsey showed the value of agility in practice. During the COVID-19 pandemic, many Chinese auto manufacturers adopted agile operations, which enabled them to quickly adjust their production lines to produce a large variety of protective equipment that greatly satisfied medical demand. The entire process of transitioning production only took a few days [69].

The information-processing capabilities inherent in ERP systems contribute to an organization's sensing capability, particularly in dynamic market demands. Through the integration process of ERP systems, updates regarding changes in market conditions are swiftly disseminated throughout the organization. The automated messaging function conveys change implications as "exception messages" to relevant decision-makers, following system-configured rules. The central database furnishes rich data for optimal response analyses to the identified changes [70]. ERP systems' powerful information processing capability can promote the sensing capabilities required by developing an MC strategy. Adopting ERP systems enables connectivity on the shop floor that supports MC. Machines and workstations can establish real-time data exchange by interfacing with the ERP system [71]. Similarly, firms leverage ERP expansion to integrate with subsystems (e.g., manufacturing execution system (MES), customer relationship management (CRM)) to enhance resource allocation, ensure swift, accurate, and secure information flow, and foster innovation in production, management, and business models, thereby aligning with MC requirements [72]. Specifically, MES facilitates the realization of MC, primarily achieved through functions such as production planning, scheduling and order release, job control-order control, and the collection of machine and operation data [73]. Furthermore, ERP systems simplify MC by effectively converting information related to consumer needs and preferences into detailed product specifications, which then can be shared with relevant supply chain members and further improve inventory management [74]. In addition, the demand forecasting module provided by the ERP system can quickly and effectively confirm the quantity of intermediate

TABLE 2. Past studies about the impact ERP on organizational agility.

Author/Year	Method	Focus	Related findings
Kharabe and Lyytinen [20]	Mixed	Organizational agility	Elevated ERP assimilation levels have a positive effect on organizational agility. Additionally, systems agility plays a pivotal role in enhancing the overall positive impact of ERP integration on organizational agility, alongside its strong direct influence.
Seethamraju and Sundar [64]	Mixed	Process agility	The impact of ERP-enabled process standardization on agility varies and is contingent on the degree of standardization deployed and whether it encompassed prior simplification efforts.
Aburub [24]	Bank	Organizational agility	While the study reveals a significant influence of ERP system utilization on banks' agility, the variance explained by ERP system use remains weak.
Almahamid and Hourani [65]	Pharm	Supply chain agility	Both intra- and inter-organizational collaboration partially mediate the influence of ERP and e-business technology integration on supply chain agility.
Almahamid [63]	Bank	Organizational agility	Users' psychological empowerment mediates ERP system usage and all agile capabilities, except for responsiveness.
Yasir et al. [21]	N/A	Organizational agility	ERP assimilation can positively and significantly affect organizational agility
Shajrawi and Aburub [66]	Hotel	Organizational agility	Organizational agility, including its various dimensions, partially mediates the connection between ERP system utilization and service differentiation, except for responsiveness, where it completely mediates.

products required by the MC according to the past sales data in the system, thus promoting the implementation of an MC strategy [61].

Responding capabilities represent an organization's capability to utilize its enterprise system resources and integrate them into its production development, systems development, supply chain and production, and flexible resource utilization [75]. Adopting ERP systems enables the integration of internal functional units and fosters connectivity with external customers and suppliers, bolstering responsiveness to market opportunities [76]. It is imperative to diligently coordinate and integrate activities across their supply chains, as such integration significantly influences their MCC [5]. When formulating MCC, managers should consider various aspects of supply chain integration, including information integration, operational integration, and relational integration [77]. Utilizing ERP systems' databases, firms facilitate data sharing with suppliers, thereby achieving information integration and enabling closer collaboration between firms and suppliers in production planning, capacity management, order delivery, and inventory levels [78]. MC also necessitates rapidly creating new products or modifying existing ones to address individual customer requirements as an integral aspect of solution space management [79]. This function can be accomplished by utilizing the product configuration module offered by the ERP system, which aims to translate customer needs, including functions and technical attributes, into a clear and distinct product representation, specifying a particular product variant. Subsequently, this information can be employed for pricing and order completion [80]. Manufacturing systems should exhibit swift adaptability, flexibility, and reconfigurability in response to short-term volume or product variations shifts, facilitating a profitable MC approach [71]. The operation management of MC takes an ERP system as the core and other management systems (e.g., supply chain management, product lifecycle management, supplier relationship management) as the auxiliary to effectively and intuitively manage enterprise resource status, product customization information, and customer and supplier information. When connected to the manufacturing execution layer, it can swiftly adapt to fluctuations in factory production processes, optimize customization product plans to address bottleneck issues, and establish the most efficient production arrangement for products [72].

Bouchard et al. [16] indicated that automation and digital technologies can enhance agility, efficiency, and performance. These improvements enable heightened responsiveness to MC demands. When firms use ERP to achieve internal and external integration, it can contribute to OA in sensing and responding, which are required to develop MCC. Thus, this study proposed the following hypothesis:

H2: A high level of ERPA can positively affect OA.

H3: OA can positively affect MCC.

H4: OA can mediate the relationship between ERPA and MCC.

E. MODERATING ROLE OF AC

Earlier studies indicated that AC significantly mediates the relationship between IT and OA [28], [81], [82]. Nevertheless, it should be noted that the practical variability in firms' AC towards ERP systems exists. As DCs, AC includes PAC and RAC, which influence the ERPA from knowledge acquisition to routinization and play a significant role in each stage of ERP [41]. AC inevitably influences the achievement of OA through utilizing ERP systems in firms. Therefore, AC can influence ERPA and its connection to OA.

More excellent AC in a firm results in a greater willingness to adopt new technology, adapt to new ERP-based business processes and assimilate ERP technical features into established routines. Which indicates a positive correlation between AC and ERPA [12]. PAC guarantees that firms possess an adequate reservoir of ERP knowledge, thereby enabling the maintenance of the system and subsequently resulting in an elevated degree of ERPA [40]. PAC is also related to the internalization of ERP knowledge. In many instances, the process of internalizing knowledge occurs following the implementation of a new ERP system and the subsequent practice by business users to acquire the necessary skills for its proficient use [83]. In comparison, the essence of RAC lies in its capability to leverage the advantages offered by ERP systems through the facilitation of enhanced utilization [40]. To enhance ERPA, firms must bolster their AC. Primarily, this necessitates a robust PAC, ensuring that the firm possesses sufficient IT knowledge to maintain the proper functioning of ERP. Based on the PAC, the RAC facilitates the firm in utilizing the system with greater efficiency, thereby attaining anticipated advantages, such as an elevated level of OA.

ERP systems' powerful data management capabilities enable swift and efficient acquisition, sharing, and analysis of information within firms, enhancing sensing capabilities. ERP systems also facilitate the internal integration of different departments and the external integration of suppliers and customers, which promotes responding capabilities. Strong AC guarantees firms acquire adequate knowledge for ERP system maintenance and optimal utilization to maximize system benefits, thereby facilitating the development of OA, particularly in sensing and responding. Therefore, a high level of AC will strengthen the relationship between ERPA and OA. Thus, this study proposed the following hypotheses:

H5: A high level of AC can strengthen the relationship between ERPA and OA.

III. METHODOLOGY

A. SAMPLE AND DATA COLLECTION

The study's targeted populations were manufacturing firms that have adopted ERP systems in Jiangsu province, China. Jiangsu Province is one of China's most advanced manufacturing provinces [84]. According to an official government report [85], Jiangsu's manufacturing industry achieved a digitalization level of 66.4% in 2022, thereby attaining the highest position in China. Various types of industrial software are extensively employed within firms, facilitating the identification of users of ERP systems with great ease.

This study employed convenience sampling, which refers to acquiring data from individuals within the population who are readily accessible and available to provide [86]. While ERP systems are prevalent among manufacturing firms in Jiangsu Province, there is a notable absence of business directories or open databases delineating specific ERP users. Consequently, we identified Jiangsu X Human Resources Co., Ltd (hereafter referred to as X Company) through personal connections, which maintains collaborative partnerships with over 1000 manufacturing firms within the province. This significantly enhances the likelihood and convenience of obtaining ERP users.

Data were collected through an electronic questionnaire on Wenjuanxing (a popular survey tool like Google Forms in China) between January and April 2023. We employed AI-powered translation tools (Youdao Translation and DeepL) and referenced corresponding Chinese scales to translate the original questionnaire items into Chinese. Subsequently, we invited three industry insiders with ERP usage experience to complete the questionnaire and requested their feedback for refinement. Given that this study included a moderated mediation model involving second-order variables and considered the established correlations among variables from prior studies, we adhered to the recommendation of [87] and opted to set an appropriate sample size within the range of 100 to 200.

Initially, we obtained an internal customer list from X Company, including 110 manufacturing firms. Then, we sent research invitations with the questionnaire link to contacts of these firms via WeChat (a popular messaging and calling app in China) through X Company's business relationship with them. Suppose his firm uses the ERP system and expresses his willingness to participate in this study. In that case, we kindly requested them to forward the questionnaire link to other employees/colleagues from different departments within his firm. To optimize the response rate, the manager of X Company assisted us in reminding participants to complete the questionnaire promptly and ensured the distribution of the questionnaire within their respective firms. Finally, 43 ERP users in the manufacturing industry participated in the survey, and we received 166 questionnaires from them. This aligned with the anticipated sample size determination.

B. MEASUREMENT

This study adopted or partially modified the questionnaires based on an extensive review of previous studies. This study adopted electronic questionnaires. This study applied a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The Chinese version, which had been meticulously translated, was employed during questionnaire distribution. The measurement items employed in our study are displayed in "Appendix."

MCC is operationalized as a manufacturer's capability to customize products while maintaining high volume, without significantly increasing costs, and with consistent quality, as well as reorganizing production processes quickly in response to customization requests [88]. MCC assessed with six items in this study was adapted from [88].

ERPA is operationalized as "the extent to which the ERP technology is used in facilitating business processes and the degree to which it supports business decision-making at operational and strategic levels [11]". ERPA assessed in this study is a second-order construct adapted from [13]. It consists of three subconstructs that evaluate the level of ERP usage in process, decision-making, and business strategy, containing eight items.

OA is operationalized as sensing capabilities reflect the firm's ability to quickly detect, interpret, and capture organizational opportunities. Moreover, responding capabilities reflected a firm's ability to mobilize and transform resources to react to the opportunities it sensed [33]. OA assessed with six items in this study was adapted from [89].

AC is operationalized as the extent to which an organization possesses the requisite know-how for assimilating the ERP artefact [90]. AC is a second-order construct adapted from [40]. It consists of two subconstructs, PAC and RAC, containing eight items.

IV. ANALYSIS AND FINDINGS

This study employed self-reported questionnaires to gather data from the identical participants across all variables. In order to guarantee the reliability of the results, it was imperative to evaluate the existence of common method variance (CMV) as described by [91]. CMV refers to the extent to which the measurement methods contribute to the observed variances rather than the constructs under investigation. To examine CMV, the current study followed the recommendation of [91] by employing Harman's single-factor analysis. Factor analysis was conducted on all measures without rotation using SPSS, resulting in six factors that accounted for 76.298% of the variance. The primary factor explained 48.372% of the total variance, which is lower than the threshold of 50%, indicating that method bias did not pose a significant concern in this study.

To evaluate this study's hypotheses, a partial least squares (PLS) approach was employed for structural equation modelling. PLS was selected for its strong and adaptable performance with varying data distributions and sample sizes, as emphasized by [92]. Additionally, PLS can handle both reflective and formative models, as highlighted by [93]. The data analysis was conducted using SmartPLS 3 software. Initially, the reliability and validity of the measurement model were assessed, and subsequently, the proposed relationships in the structural model were examined. To ascertain the significance levels of loadings, weights, and path coefficients, the bootstrapping technique with 5,000 resamples was utilized, following the recommendation of [92].

TABLE 3. Measurement model (first order).

	Items	Loading	α	Roh	CR	AVE
ERPA1	ERPA1.1	0.78	0.78	0.801	0.87	0.691
	ERPA1.2	0.861				
	ERPA1.3	0.852				
ERPA2	ERPA2.1	0.837	0.812	0.813	0.889	0.728
	ERPA2.2	0.908				
	ERPA2.3	0.812				
ERPA3	ERPA3.1	0.886	0.882	0.886	0.927	0.809
	ERPA3.2	0.94				
	ERPA3.3	0.871				
MCC	MC1	0.852	0.933	0.935	0.947	0.749
	MC2	0.805				
	MC3	0.887				
	MC4	0.88				
	MC5	0.864				
	MC6	0.901				
OA	OA1	0.91	0.941	0.943	0.954	0.774
	OA2	0.862				
	OA3	0.881				
	OA4	0.885				
	OA5	0.883				
	OA6	0.855				
PAC	PAC1.1	0.644	0.887	0.898	0.919	0.696
	PAC1.2	0.877				
	PAC2.1	0.899				
	PAC2.2	0.859				
	PAC2.3	0.868				
RAC	RAC1	0.943	0.937	0.938	0.959	0.887
	RAC2	0.95				
	RAC3	0.933				

A. ASSESSMENT OF MEASUREMENT MODEL (FIRST ORDER)

The measurement model establishes the connection between latent constructs and their associated items. In this study, the measurement model comprised both first-order and second-order components. In the first order, all latent constructs were reflective; thus, their validity and reliability were assessed. Reliability was determined using factor loading and composite reliability (CR) measures. In this study, all variables' factor loadings and CR exceeded 0.7, indicating satisfactory reliability at both the item and construct levels (Table 3).

TABLE 4. Discriminant validity (Fornel-Larcker's method).

	ERP1	ERP2	ERP3	MCC	OA	PAC	RAC
ERPA1	**0.832**						
ERPA2	0.608	**0.853**					
ERPA3	0.443	0.631	**0.9**				
MCC	0.468	0.463	0.534	**0.865**			
OA	0.493	0.591	0.649	0.74	**0.88**		
PAC	0.5	0.492	0.509	0.545	0.553	**0.834**	
RAC	0.509	0.503	0.557	0.535	0.573	0.758	**0.942**

Convergent and discriminant validity were assessed to determine the validity of the measurement model [94]. All variables' average variance extracted (AVE) exceeded 0.5, meeting the required criterion.

To examine discriminant validity, this study adopted the Fornell and Larcker criteria [95] and the HTMT method. Based on Table 4, the square root of the average variance extracted (AVE) exhibited higher values on the diagonal compared to the corresponding values in columns and rows. In addition, according to Table 5, all values are less than 0.85. Therefore, the discriminant of this study was achieved.

B. ASSESSMENT OF MEASUREMENT MODEL (SECOND ORDER)

The utilization of second-order constructs necessitates the inclusion of multiple latent constructs and can be theoretically distinguished from first-order constructs. In the present investigation, the second-order variables demonstrate reflective-reflexive characteristics. As a result, the criteria for assessing reliability and validity remain consistent. The indicators for ERPA and AC all satisfy the predetermined thresholds, as indicated in Table 6 and Table 7. Consequently, the measurement model is valid for the second-order construct. Subsequently, the measurement model demonstrates satisfactory validity and reliability at both the first and second orders, enabling progression to the subsequent analysis stage.

C. STRUCTURAL MODEL ASSESSMENT

In this study, the structural model was evaluated using path coefficients, coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2) measures [94], [96], [97], [98]. The significance level of the path coefficient was determined using a bootstrapping procedure with 5,000 resamples, as recommended by previous studies [99].

The findings in Table 8 provide an overview of the path coefficients, standard errors, associated t-values, and the explanatory power of the estimated model, denoted by the R^2 values. ERPA $\beta = 0.523$, $p < 0.01$) was related positively to OA. Thus, H2 was supported. Then, OA $\beta = 0.647$, $p < 0.01$) was related positively to MCC, supporting H3. However, ERPA does not affect MC; therefore, H1 was rejected.

The results showed that ERPA and OA accounted for 55.8% of the variance in MCC. Specifically, ERPA explained 52% of the variance in OA. To evaluate the magnitude of the effects, as recommended by [94], the effect size (f^2) was calculated. The effect size, determined by Cohen's equation [100], quantifies the significance of exogenous variables in explaining the variance within the endogenous construct. He suggested that effect size values of 0.35, 0.15, and 0.02 correspond to substantial, moderate, and weak effects.

In this study, ERPA revealed a weak effect ($f^2 = 0.021$) on the variance explanation MCC. However, the results indicated a strong effect ($f^2 = 0.329$) of ERPA in explaining the variance observed in OA. As stated by [101], a Q^2 value exceeding 0 signifies the predictive relevance of the model. The Q^2 values for MCC ($Q^2 = 0.409$) and OA ($Q^2 = 0.397$) in this study were both above 0, indicating that the model demonstrates satisfactory predictive relevance (Table 8).

In order to examine H4, which posited that OA acts as a mediator in the relationship between ERPA and MCC, the author employed Preacher and Hayes' [102] bootstrapping method to assess the indirect effect. By utilizing 5,000 resamples for the bootstrapping analysis, the results indicated that the indirect effect, denoted as $\beta = 0.362$, was statistically significant, as evidenced by a t-value of 6.528. Furthermore, the 95% confidence interval, CI: [LL = 0.261, UL = 0.471], did not include the value of 0, lending additional support to the significance of the mediation effect of OA. Consequently, the authors concluded that H4 was substantiated (Table 9).

To explore the moderating impact of AC on the relationship between ERPA and OA, the product indicator approach, as described by [94], was employed. The findings presented in Table 9 and Fig. 3 provided evidence in favor of the interaction effect ($\beta = 0.085$, $p < 0.01$). These results imply that AC has the potentil to moderate the association between ERPA and OA. Therefore, H5 was supported.

V. DISCUSSION

This study mainly investigated whether ERPA can affect MCC through OA in manufacturing firms. In addition, this study also tested whether AC could moderate the relationship between ERPA and OA. The analysis results partially supported the hypotheses.

This study found no significant relationship between ERPA and MCC, not supporting H1. This finding did not come as a

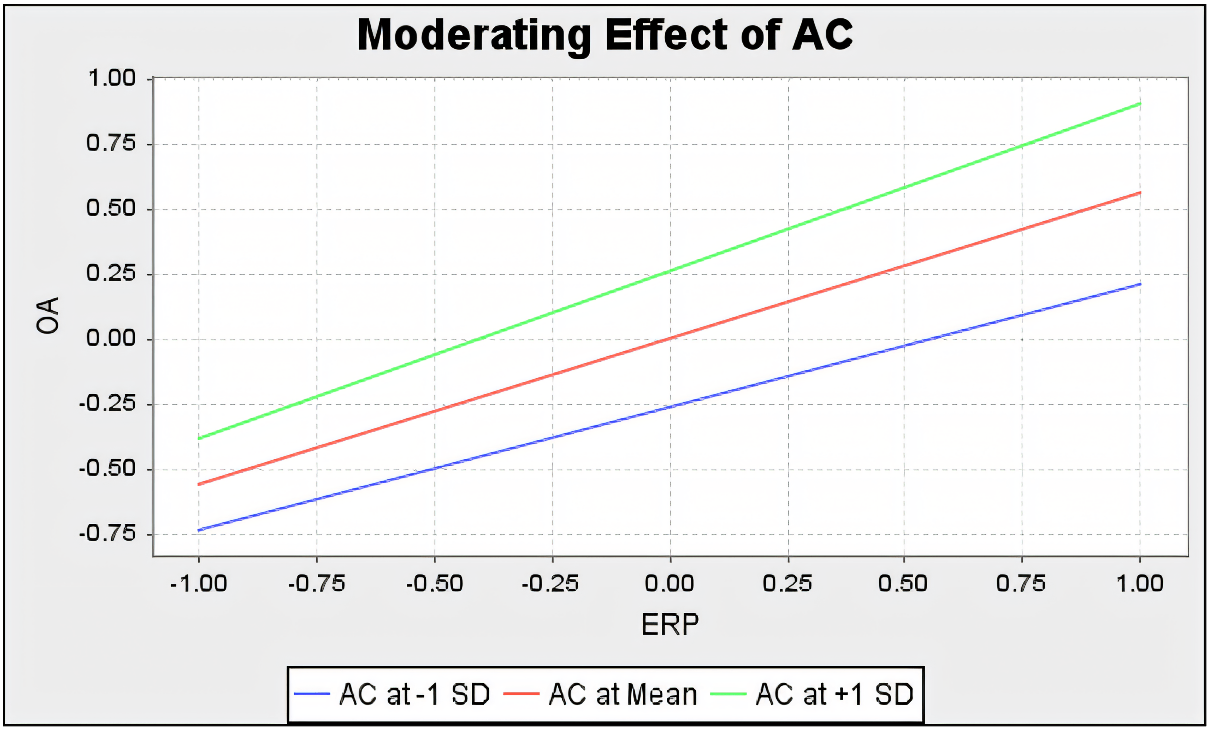

FIGURE 3. Interaction effect.

surprise, given its alignment with prior empirical results [4], [9]. Presently, the ubiquitous nature of information and communication technology (ICT) renders it readily obtainable for firms in the marketplace, posing a challenge for them to attain a distinctive competitive edge solely by leveraging ICT [103]. It explained that the utilization of ERP systems does not exert a substantial influence on MCC. Because regardless of whether the MC performance is favorable or unfavorable, organizations universally rely on ERP systems [9]. Thus, firms must use ERP systems with other organizational capabilities to facilitate the development of MCC and then achieve competitive advantages.

Concerning the impact of ERPA on OA, a substantial correlation was observed between them, thus supporting H2. This favorable result aligns with previous studies [20], [21], [104]. Previous studies investigating the impact of ERP usage on OA in non-manufacturing industries such as banking and hospitality have reached the consensus that ERP usage does not fully support the development of OA [24], [63], [66]. Conversely, this study found that ERPA can fully support OA. A plausible rationale could be attributed to industry variances, where users within the manufacturing sector perceive an advantage offered by ERP systems in facilitating swift adaptation, modification, and reconfiguration of production systems instead of operating without enterprise systems.

In relation to the influence of OA on MCC, a notable association was observed between them, thus providing support for H3. This result aligns with a previous study that demonstrated that OA exerts a positive impact on MCC [84]. This

TABLE 5. Discriminant validity (HTMT method).

	ERP1	ERP2	ERP3	MCC	OA	PAC	RAC
ERPA1							
ERPA2	0.75						
ERPA3	0.522	0.749					
MCC	0.539	0.531	0.588				
OA	0.558	0.675	0.711	0.787			
PAC	0.59	0.579	0.572	0.596	0.603		
RAC	0.583	0.576	0.61	0.572	0.608	0.825	

study confirms the value of OA that integrates agility into MC, which helps firms to respond to fluctuating customer demands and volatile market needs quickly [105].

OA fully mediated the relationship between ERPA and MCC, supporting H4. This finding is partially consistent with the existing study on the mediating role of supply chain agility between big data analytics capability and MCC [106]. Therefore, a high level of ERPA is not fully guaranteed to promote the improvement of MCC. In order to maximize the advantages offered by digital technologies, firms need to possess a certain degree of OA [107]. To achieve MCC, a firm must translate the usage of an ERP system into OA.

Regarding the moderation effect of AC, H5 was supported. This result revealed that the variation in agility among ERP users can be attributed to the discrepancy in their AC towards the system. If firms possess a considerable degree of absorption capacity, ERPA will exert a robust impact on their OA

TABLE 6. Measurement model (second order).

Construct	Items	Loadings	α	Roh	CR	AVE
ERPA	ERP1	0.789	0.793	0.801	0.879	0.707
	ERP2	0.886				
	ERP3	0.845				
AC	PAC	0.935	0.862	0.863	0.935	0.879
	RAC	0.94				

TABLE 7. Discriminant validity (Fornell-Larcker's method, second order).

	AC	ERPA	MCC	OA
AC	**0.937**			
ERPA	0.65	**0.841**		
MCC	0.576	0.583	**0.865**	
OA	0.601	0.693	0.741	**0.88**

and vice versa. Undoubtedly, it is worth acknowledging that firms allocate varying resources towards fostering AC, resulting in disparate levels of association between ERPA and OA.

This study presents a framework for leveraging ERP systems to cultivate MCC. Prior research has recognized ERP systems as comprehensive management systems that integrate multiple subsystems, offering practical functionalities aligned with the developmental needs of MCC [73]. Positioned as a crucial IT resource for firms, ERP systems, when viewed through the lens of DCs, necessitate the development of advanced organizational capabilities, specifically OA, to effectively contribute to enhancing MCC. However, the utilization of ERP, being a complex system, for fostering OA is contingent upon the AC of the firm itself. Only firms possessing a high level of AC can attain the desired OA, thereby facilitating the development of MCC and enabling competitive advantages.

VI. IMPLICATIONS

A. THEORETICAL IMPLICATIONS

This study has two main theoretical implications. First, this study successfully connected ERPA and MCC through OA as mediator, which has been a lack of evidence establishing a direct correlation in previous studies [9]. DCV provides theoretical support that explains how ERPA affects the development of MCC in manufacturing firms. In this study, OA represented DCs, which were conceptualized as sensing and responding capabilities. The findings reaffirm that ERP systems continue to serve as crucial facilitators of OA in enterprise systems research. Most importantly, the findings expand the significance of OA within the context of MC research, emphasizing OA as a pivotal higher-order DCs for cultivating MCC. Hence, to foster MCC through ERP systems, firms must utilize the systems to attain the OA essential for MCC.

Second, this study strengthens the understanding of the relationship between ERPA and OA by introducing AC as a moderator. This study answered speculation from [24] that establishing agility via ERP systems may be contingent upon additional variables. The findings offer a more extensive clarification of the contextual limitations influencing the relationship between ERPA and OA. The findings validate the significance of AC in the establishment of OA within the realm of enterprise systems research. Hence, if firms want to obtain a high level of OA enabled by ERP systems, they must possess strong AC.

B. MANAGERIAL IMPLICATIONS

Our study also presents practical recommendations for ERP-using firms. In the contemporary business landscape, manufacturers frequently encounter diverse customization requests from customers, often characterized by small order quantities and numerous variants, such as different colors and sizes within a single order. Ignoring such orders could result in missed profit opportunities. Consequently, to better meet customer demands and survive in intense competition, firms must cultivate MCC. Beyond employing necessary customization practices like configuration technology, product and process modularization, or postponement, firms also need to leverage ERP systems to manage the entire production and operational process. This study's findings emphasize that firms must enhance OA, specifically sensing and responding capabilities, by utilizing ERP systems for efficient MC implementation. Therefore, the study recommends elevating digitalization levels within the organization, eliminating information silos to facilitate the internal integration of ERP and its subsystems. This promotes real-time information sharing among departments, enabling visualized management. Simultaneously, the study suggests interfacing with supplier ERP systems to share inventory information and enhance collaboration. Indeed, this falls significantly short; firms must additionally engage in the continuous real-time assessment of customer demands. Murata Manufacturing [108] posits that the foundational technologies for achieving MC are continually evolving. It suggests that firms embrace digital marketing to digitize customer demands, employing artificial intelligence to infer and formulate product specifications that fulfill requirements based on historical sales and marketing data. This can be facilitated through the CRM module within ERP systems. Furthermore, IoT One [109], a consultancy dedicated to digital transformation, recommends that firms employ interactive product configurators to swiftly gather customized requirements from customers. This functionality can be implemented through the product configurator module within ERP systems.

AC determines the extent to which ERPA enhances OA. An empirical study shows that a lack of knowledge management systems and formal post-implementation training programs are major issues affecting AC and will impede ERPA within firms [42]. In reality, due to the inadequate allocation of internal resources, numerous firms face challenges in ERPA due to their limited AC to effectively absorb

TABLE 8. Assessment of structural model.

Hypothesis	Relationship	Path coefficient (β)	SE	t-value	R^2	F^2	Q^2	Decision
H1	ERPA -> MCC	0.134	0.069	1.956	0.558	0.021	0.409	Not supported
H2	ERPA -> OA	0.523	0.062	8.448	0.52	0.329	0.397	Supported
H3	OA -> MCC	0.647	0.068	9.494		0.492		Supported

TABLE 9. Assessment of mediating and moderating effect.

Hypothesis	Relationship	Indirect	SE	t-value	CI: [LL-UL]	Decision
H4	ERPA -> OA -> MCC	0.362	0.055	6.528	0.261-0.471	Supported
H5	ERP -> OA × AC	0.085	0.03	2.861	0.023-0.139	Supported

ERP innovation into their business operations [29], further hindering the leverage of ERP systems to achieve OA. Hence, firms must allocate sufficient resources to train employees in ERP usage. Developing employee skills for complex ERP systems demands special training that differs from office suites. Additionally, knowledge transfer for consultants may be difficult when dealing with non-IT-literate individuals. Training for ERP systems often incurs hidden costs for organizations, and neglecting employee training can lead to problems [110]. Training is essential to enhance individual AC. Proper training can compensate for the deficiency in prior related knowledge and educational background in related fields. Users with different educational backgrounds can become proficient ERP users and progress in the assimilation hierarchy through adequate training. It is argued that individual ERPA has a direct correlation with organizational ERPA [111]. In practice, although firms delivering ERP systems use training for their employees, there remains a deficit in employees' understanding and motivation to effectively engage with the ERP systems [112]. As an illustration, organizations can improve employee satisfaction by implementing reward and punishment systems to enhance users' ongoing utilization of ERP systems. Furthermore, firms should offer leadership development programs to their management, fostering an environment wherein direct supervisors actively monitor the regular usage of corporate systems, oversee user advancement, and promptly recognize and rectify emerging issues [113].

VII. LIMITATIONS AND FUTURE RESEARCH

This study is not devoid of limitations. Firstly, this study utilizes a relatively small sample size of 166 questionnaires collected from 43 ERP-adopting firms through a non-public source. Although the sample size meets the requirements of running statistical techniques, high-quality statistical results necessitate a larger sample size. Hence, we recommend that future studies seek collaboration with ERP vendors, authoritative consultancy firms, or governmental entities to obtain a larger sample size and enhance the validity of our findings. Secondly, constrained by time and budget, this study focused solely on the manufacturing sector within Jiangsu Province, China. Given China's regional economic disparities and substantial cultural variations, the findings may not be generalized nationwide. Hence, future studies may explore other economically developed provinces, such as Zhejiang and Guangdong, and further engage in comparative analyses of regional disparities, such as those between the Yangtze River Delta and the Pearl River Delta. Thirdly, this study has exclusively examined the general manufacturing sector. In practical terms, due to industry-specific variations, the adoption of distinct ERP solutions and corresponding MC strategies varies. Therefore, future studies could employ a mixed-methods approach to investigate specific industries, offering valuable insights. And future studies could use bibliometric analysis to provide a more comprehensive viewpoint of ERP application in MCC [114], [115], [116].

The findings highlight various prospects for future study. Firstly, in the context of Industry 4.0, the forthcoming study may explore the influence of cutting-edge technologies, such as big data, the Internet of Things, and cloud computing, on MC. Moreover, how to integrate these emerging technologies with existing ERP systems to improve the efficiency of MCC. Secondly, future studies could investigate the impact of other manufacturing practices, such as lean manufacturing, on MCC. Moreover, it explores the how to leverage these manufacturing practices to improve MCC. Thirdly, given the technological maturity of cloud-based ERP systems, their implementation costs are comparatively lower than on-premise ERP solutions, and their configurations are more flexible, allowing firms to select modules based on their specific requirements. This presents opportunities for the development of MCC within SMEs. Consequently, future studies may explore how SMEs can strategically leverage cloud-based ERP systems to foster the growth of MCC.

APPENDIX

Questionnaire

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LIU ZONGYUAN received the Bachelor of Marketing degree from Guangling College, Yangzhou University, in 2019, and the Master of Business Administration degree from the Azman Hashim International Business School, Universiti Teknologi Malaysia, in 2021, where he is currently pursuing the Ph.D. degree. His research interest includes SMEs management.

HUO HAIYAN received the Bachelor of Management degree in engineering management from the Great Wall College, China University of Geosciences, in 2015, and the Master of Management degree in industrial engineering from China University of Mining and Technology, in 2019. She is currently pursuing the Ph.D. degree with the Azman Hashim International Business School, Universiti Teknologi Malaysia. Her research interests include marketing and consumer behavior.