Manufacturer's Contexts, Supply Chain Risk Management, and Agility Performance

Mohsin Jat, Muhammad S. S. Jajja, Attique ur Rehman, and Sami Farooq

***Abstract*—The dynamism of the current business environment emanates significant challenges and disruption risks for supply chains. These vulnerabilities in contemporary supply chains have motivated a substantial academic focus on supply chain risk management (SCRM). In the empirical literature on SCRM, a firm's external environment is conceptualized as a source of risk, and various organizational and technological factors are discussed as influencers of SCRM. However, the factors studied in the literature are generally narrow and analyzed in isolation, which has resulted in a fragmented and inconsistent understanding of the role of organizational and technological setups in SCRM. This study offers a systematic understanding of the antecedents and consequences of effective SCRM by investigating the associations between a manufacturer's environmental, organizational, and technological contexts, SCRM, and agility. The study employs the information processing view as the primary theoretical lens and relies on large-scale multi-industry and multicountry survey data for empirical analysis. In contrast to the threat-rigidity thesis, the findings of this study suggest that manufacturers seek collaborative and flexible work settings to respond to environmental challenges. Besides increasing efficiency, such organizational settings and enhanced technological setups can increase information processing capability to enable SCRM and agility. These findings challenge the suggestions that initiatives taken for efficiency can increase the risk factor and deteriorate performance. The study provides novel insights into the underlying information processing mechanisms for effective SCRM and highlights the importance of organizational and technological setups in enhancing these core mechanisms.**

***Index Terms*—Agility, business environment, information processing, organizational context, risk management, technological context.**

I. INTRODUCTION

MANUFACTURERS in contemporary supply chains are exposed to challenging environments in which technologies change rapidly, competition is extensive, and pressures for cost reduction and innovation are high. To deal with some of the challenges, manufacturers pursue strategies like lean operations and just-in-time (JIT) production, which, on their own, are difficult to apply and manage [1], [2]. Under environmental challenges and, consequently, complex strategies, manufacturers are prone to significant disruption risks [3]. The challenges and complexities hamper predictability and the manufacturers' ability to manage undesirable events in supply chains [4], which can lead to adverse consequences on a wide scale [5]. The year 2000 fire at the Philips semiconductor plant, the 2002 bankruptcy of a critical supplier of Land Rover, the 2011 Japan tsunami, and the 2012 fire at a garment factory in Bangladesh are widely reported disruption instances that had crippling effects on the impacted supply chains. A recent global survey by Deloitte [6] found that more than 80% of the participating organizations experienced disruptions in the recent past. In comparison, only 1% was optimized to address important risk management issues. The same report highlighted the positive role of collaborative organizational structures and technology in supply chain risk management (SCRM). Similarly, a special report by McKinsey [7] stated that the companies that successfully navigated through the COVID-19 crisis were the ones that invested in technology and people to enable agility.

In supply chain management literature, risk management is identified as a growing research stream [8]. Although there have been several attempts to investigate the measures for effective SCRM empirically, the need for further research is significant [5]. Specifically, while the literature has extensively focused on the capabilities and strategies of SCRM, comparatively less is known about the factors or antecedents that enable these capabilities and strategies [9]. Understanding the enablers can ensure the successful development and deployment of SCRM strategies to control firm performance. For example, integration has been argued as an effective SCRM strategy [2], [5] while integration itself relies on social and technical factors [10].

The empirical literature on SCRM suggests various environmental, organizational, and, more recently, technological factors as influencers of risk and its management. The environment has been generally studied as a context emanating uncertainty and risks [1], [11], [12]. In the organizational context, authors have studied the impact of factors such as human capital [13], learning orientation [14], culture [15], management control system [16], resource reconfiguration ability [17], integration

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and collaboration [2], [5], and lean practices [12]. On the rather limited technological side, the impact of Industry 4.0 technologies [18], data analytical capabilities [19], and artificial intelligence [20] have been studied. Although the studies mostly suggest a positive impact of the analyzed organizational and technological initiatives on risk management and performance, opposing arguments can also be found. For example, it is argued that integrative settings can increase risk exposure and reduce flexibility [21], [22], lean practices can increase fragility against disruptions [12], and induction of manufacturing technologies can increase complexity and risk [23].

Besides providing an inconsistent understanding, the empirical studies on SCRM do not generally conceptualize the organizational and technological factors as simultaneous enablers of SCRM. The exceptions include [13], [19], [24]. Adopting the theory-building approach with case studies, Blackhurst et al. [13] propose a conceptual framework linking resilience with human and physical resources. They suggest future research to focus on the empirical generalization of the role of resilience enhancers (physical and human capital) and resilience reducers (environmental factors). Dubey et al. [24], focusing on the Indian context, study the role of connectivity infrastructure and the nature of supply chain relationships in resilience. More recently, again based on an Indian survey, Dubey et al. [19] investigate the role of data analytics and organizational reconfiguration ability in dealing with disruptions. It is also notable that the extant studies consider narrow organizational factors and specialized technologies, which can be linked with organizational and technological contexts but do not define the broader nature of these contexts.

The empirical literature on SCRM while indicating the role of different factors in dealing with supply chain risks provides a fragmented understanding of the antecedents of SCRM. Regarding the consequences, the literature has widely recognized agility performance, i.e., delivering the desired outcome, regardless of undesired events [25], as an anticipated outcome of SCRM and a necessity for firms facing supply chain risks [26], [27]. We argue that understanding the antecedents and performance consequences of effective SCRM merits a more broad-based investigation by explicitly considering the technological and organizational contexts of a manufacturer in relation to the external factors posing risks. An analysis of how these contexts and their interplay influence SCRM and agility performance can unveil the overall dynamics for effective SCRM beyond building excess or slack resources—a standard and costly approach for SCRM [1]. With this objective, our study seeks to answer the following questions based on cross-industry and multicountry survey data from 325 manufacturers:

> *RQ-1: Does a challenging environment drive enhancements in a manufacturer's organizational and technological contexts*?

> *RQ-2: Do enhanced organizational and technological contexts of a manufacturer improve its SCRM effectiveness and agility*?

We relate environmental challenges to the volatility and competitiveness of the landscape in which the manufacturer functions. The organizational context is defined as the extent to which the organizational setup is conducive, considering the level of decentralization, flexibility, and collaborative climate. The technological context is characterized by the extent of the implementation of tools and technologies for communication and information integration across production phases and departments.

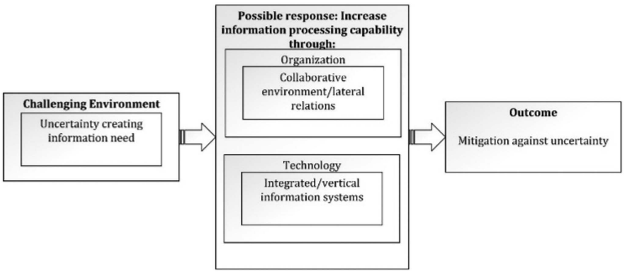


Fig. 1. ITP and the contexts.

This study employs the information processing theory (IPT) and adopts elements of the technology–organization–environment (TOE) framework to conceptualize the relationships between the contextual aspects of a manufacturer, the effectiveness of SCRM, and agility performance. The TOE framework explains technology, organization, and environment as three different but connected elements in a firm's context. Widely used to explain innovation adoption, the framework is highly flexible in accommodating various factors [28]. Arguing that TOE elements can also help understand the enablers of SCRM, we use the TOE framework and IPT to synthesize an empirical model for analyzing the aforementioned relationships. IPT explains the role of organizational and technological structures in building information processing capabilities and the role of these capabilities in dealing with environmental uncertainties [29]. Risk being a product of uncertainty [8] and SCRM being an information-intensive process [2], IPT can explain why a challenging environment may require technology deployment and conducive organizational design for effective SCRM and agility.

II. Theory and Hypotheses Development

A. *ITP and TOE Contexts*

Introduced by Galbraith [29], IPT views organizations as primarily information processing systems and posits that information availability and its use have a positive link with performance [11], [15]. The theory suggests that organizations seek the best arrangement of their work units to enable the effective collection, processing, and distribution of information [15], [29], [30]. Consequently, organizations can enhance their information processing capabilities and information flow to deal with uncertainties [30].

The TOE framework, which has generally been used in technology and innovation literature, describes three contexts of a firm. The environmental context includes factors related to the changes and competitiveness of the market, the technological context relates to the current level of technology implementation by the firm, and the organizational context relates to the firm's organizational design and behavior. Although generic and rather unevolved, the framework provides opportunities for theoretical synthesis and extensions [28]. Gilani et al. [31] show that a theoretical synthesis can extend and enrich the TOE framework by including facets of organizational performance. We argue that IPT implicitly captures and links TOE contexts (see Fig. 1). IPT explains the role of information processing capabilities, which can be enhanced by adopting appropriate organizational structures and technologies (organizational and technological contexts) in dealing with the uncertainties of the environment.

IPT suggests that a challenging environment gives rise to uncertainty [32], [33], creating an increased need for information [29]. To deal with this, firms can either deploy the "mechanistic" organizational approach to lower their information need or increase their capacity to process information. The mechanistic approach uses labor division and centralization to manage interrelated work. It is a hierarchical approach in which employees refer to "exception scenarios" to managers for resolutions. The drawback of this approach is that a large number of resolution requests, due to high uncertainty, can overwhelm managers. Alternatively, a firm can create self-contained tasks or develop a collaborative environment with lateral relations, in which different functional units, e.g., procurement, production, marketing, and logistics, jointly plan and execute an assignment. Another way to avoid mechanistic mechanisms is to deploy vertical and integrated information systems to enhance information processing capacity. These systems can allow efficient and intelligent processing of information while performing a task and enable efficient and rapid planning [29].

Supply chain and operations management scholars have widely applied the information processing view as a theoretical basis [2]. Fan et al. [11], [15] note that despite the merits of applying IPT to study uncertainty and risk, only a few authors have used the information processing lens in SCRM research. Similarly, despite making explicit references to the environmental, organizational, and technological factors, IPT has not been used to conceptualize these broader contexts of an organization in an empirical study. IPT provides a strong underpinning for connecting the contexts with SCRM and organizational performance.

B. Supply Chain Risk Management

Although there is no broadly accepted conceptualization of risk, on the fundamental level, the term "risk" has been linked to the uncertainty dimension of events with negative consequences on objectives [8]. In supply chain management literature, the terms "risks," "vulnerabilities," and "disruption possibilities" have been used interchangeably [34] and are connected to the dynamism, complexity, and unpredictability of the business environment [2], [35]. Supply chain risk can be defined as the extent to which supply chain outcomes are variable or susceptible to disruption and, thus, may be detrimental to the supply chain [36]. More specifically, supply chain risks are associated with probable events that disrupt the firm's key supply sources, internal operations, and delivery means [5], resulting in a deviation from objectives and deterioration of value addition [34]. Several studies have exclusively focused on the classification of risk sources. For example, Ritchie and Marshall [37] identify environmental, industrial, and organizational factors as the primary sources of risks. Rao and Goldsby [38] offer a more comprehensive framework by adding problem-specific and decision-maker sources of supply chain risks.

The management of supply chain risks has also been viewed from different standpoints. One of the views captures SCRM as a process aimed at identifying, assessing, treating, and monitoring supply chain risks based on a set of capabilities and strategies [39]. Broadly, the goal of SCRM is to build and maintain resilience in a supply chain [16], [40] by deploying measures that can prevent disruptions or minimize their undesirable effects [36]. Speier et al. [36] conceptualize SCRM as activities in four interconnected stages. They suggest that organizations capable of appropriately preventing, detecting, responding to, and recovering from a disruptive incident within the supply chain create resilience. Prevention is based on acknowledging that undesirable events can occur in the supply chain and averting the actions that can lead to these events. Detection is the ability to recognize an incident ideally before it does any harm. On the other hand, response and recovery are reactive stages that involve short- and long-term efforts, respectively, to bring the necessary services and systems back on track and restore the supply chain. In this study, similar to [2], [34], [36], SCRM effectiveness is gauged based on the level of prevention and detection of, response to, and recovery from supply chain disruptions.

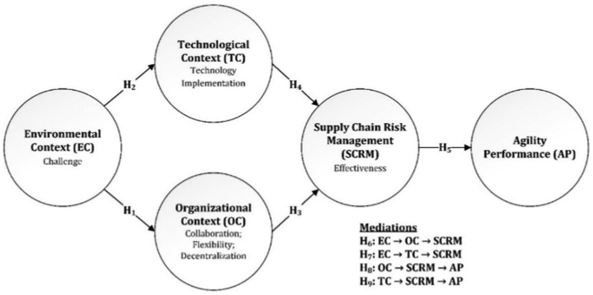


Fig. 2. Hypothesized model. $*p < 0.05$; $**p < 0.01$; $***p < 0.001$ (EC: Environmental context; OC: Organizational context; TC: Technological context; SCRM: Supply chain risk management; AP: Agility performance.).

The literature points to organizational and technological factors as enhancers of SCRM. The organizational domain has received a significant focus. The reported organizational factors that contribute to SCRM include a conducive work environment, continuous improvement [34], people involvement, deliberation [8], organizational (internal) integration, and inclusive decision-making [41]. The role of technological factors in SCRM has received less attention. While highlighting the scarcity of work in this area and the need for better understanding, Ivanov et al. [23] presented a conceptual framework describing the relationship between various technologies and supply chain risks.

We capture both organizational and technological facets of a manufacturer's contexts and analyze their link with SCRM effectiveness (see Fig. 2) to understand how organizations can be strengthened against the risks posed by a challenging environment. We analyze agility performance rather than the financial consequences of effective SCRM because implementing risk management practices often escalates costs [42]. SCRM may, however, indirectly influence financial performance by providing flexibility [43]. Being responsive to market needs can be considered a necessity for manufacturers in an uncertain environment [26], hence a more immediate objective.

C. Agility Performance

The literature on supply chain management has conceptualized agility as a paradigm, strategy, capability, and performance [5]. Researchers have also mixed these dimensions in operationalizing agility [44]. This research conceptualizes agility as performance, which is appropriate considering that the inclination of an organization to perform on agility metrics is linked to environmental challenges [27]. Authors have argued that environmental uncertainty motivates organizations to compete on agility [14]. Positive outcomes on agility metrics signify success in an unstable and dynamic environment [25].

As a performance, agility is related to efficiency and responsiveness in terms of product customization, product development, changeovers, and operation scale [44], [45]. Studies have also linked agility performance to output quality [44]. This study refers to agility performance as a mix of performance metrics related to organizational responsiveness to the design, quality, and delivery needs of the market [25], [44].

D. Linking Technological, Organizational, and Environmental Contexts

The three contexts in the TOE framework have primarily been considered independent. Gillani et al. [31] and Oliveira et al. [46] diverge from the general conceptualization of the framework by suggesting a sequential rather than simultaneous impact of the contexts. This study also argues for interdependence between the contexts and posits an influence of the external environment on a firm's technological and organizational contexts.

The environmental context, representing the external pressures faced by a firm [47], can be defined by competitive rivalry, product substitution threat, technological dynamism, and customer power [48]. These factors have also been labeled as sources of industrial risks [38]. Firms need to devise strategies and organizational practices that align with the external environment [33], [49]. A challenging or volatile environment requires organizational practices that can handle unexpected changes [32]. These practices can include decentralization, employee empowerment, flexibility, coordination, collaboration, and improvement, which are closely linked to lean and JIT principles and allow timely decisions [50]. Flexibility in organizational structures allows employees to be more versatile and better equipped to deal with changes in the environment [51]. IPT presents a similar argument by suggesting that firms can increase their information processing capacities through collaborative settings and lateral relations to deal with environmental uncertainties. An enhanced information processing capability can make mechanistic organizational means redundant and hence avoid overwhelming management in highly uncertain situations. Characterizing a manufacturer's organizational context by the extent of flexible and collaborative organizational practices and structure [31], [50], [51], our first hypothesis is as follows:

> *H1: A challenging environmental context positively impacts the organizational context of a manufacturer.*

Besides work practices, an uncertain and competitive business environment requires firms to enhance their technological base to achieve efficiency and remain competitive [52]. Evolving customer demand and technological advancements cause firms to upgrade technologically to meet production requirements [53]. Information and communication technologies facilitate uninterrupted information exchange in organizations [51], ensuring the distribution of essential information across hierarchies and departments for effective decision-making to deal with environmental dynamics [54]. IPT supports this argument by suggesting that the exhaustion of mechanistic measures in uncertain situations can be avoided by developing vertical and integrated information systems to enhance information processing capacity. These systems enable organizations to process information efficiently and intelligently while performing tasks, thereby allowing rapid and efficient creation, adjustment, and deployment of plans. Defining the technological context as the extent to which a manufacturer implements tools and technologies for communication purposes and the integration of information and knowledge in its production processes [31], we hypothesize the following:

> *H2: A challenging environmental context positively impacts the technological context of a manufacturer.*

H1 and H2 are also supported by the dynamic capabilities view (DCV), which suggests that firms operating in a dynamic environment need to develop capabilities to manage uncertainties [5] and stay competitive [55]. A competing argument, mainly against H1, can be found in the threat-rigidity thesis, suggesting a restriction of information processing and constriction in control under a threatening environment [56]. The thesis argues that an organization's decision-making becomes more conservative, centralized, and inflexible in high-risk situations [12] to enhance the control of an organization's actions [56]. However, whether a threatening environment causes rigidity or flexibility has remained an unresolved question [57]. Both competing viewpoints have conceptual and empirical support [12], [57].

E. Contexts and SCRM

Risks in supply chains arise from uncertainty or a lack of information on supply chain activities [8]. Information sharing, which enhances supply chain visibility [58] and reduces uncertainty [59], is a primary requirement for achieving the goal of SCRM to build and maintain resilience against disruptions [15], [40]. Evidence and knowledge around the disruption phenomena form the foundation for risk decision-making [8]. Therefore, the conditions that support information sharing and flow, for example, collaboration [60] and integration [61], should facilitate risk management [15]. As argued in Section II-D, conducive work settings and technologies for communication and integration enable information flow. Hence, these factors in a firm's context should also facilitate SCRM.

In supply chains, information distribution to partners is essential for a shared understanding [62]. Information acquired from the demand side needs to be distributed on the supply side to bind the supply chain together [63]. However, information exchange with customers and suppliers is only possible when the firm can robustly coordinate and exchange information internally [64]. For this, lean structures, autonomy, decentralization, and coordination play a positive role [50]. A highly hierarchical structure can create silo-based risk management processes, which can negatively impact the overall effectiveness of risk management [65].

Information dissemination with employee autonomy and lean practices enables responsive resolution of issues [66] while inclusiveness and collaboration alleviate circumstances such as disputes that aggravate risks [41] and ensure robust planning [51], [64]. Considering that a better organizational context reduces both impact and probability of disruptions [34], we hypothesize the following:

H3: An enhanced organizational context is positively associated with SCRM effectiveness.

In the technological context, manufacturing and communication technologies allow accurate and efficient information exchange among functional departments and facilitate internal integration [31]. Similarly, the assimilation of technologies enables external integration by leveraging the seamless exchange of data and information between the manufacturer and its partners [67]. Manufacturing and communication technologies also enable the implementation of more advanced technologies [31], [68], such as track and trace, radio-frequency identification, and 3-D printing [31], which can further reduce risks [23]. For example, track and trace systems can lower supply risks by providing real-time coordination when implementing contingency policies [23]. This leads us to hypothesize the following:

H4: An enhanced technological context is positively associated with SCRM effectiveness.

IPT supports the propositions in H3 and H4 by signifying the role of initiatives such as the set-up of internal coordination mechanisms (organizational context) and investments in suitable information systems (technological context) in mitigating the effects of uncertainty or risks. An alignment between a flexible organization structure and a procedural implantation of information sharing through technology can increase the fit between information processing capabilities and requirements imposed by uncertainty [9]. This fit is positively linked with SCRM capabilities [2], [9].

F. SCRM and Agility Performance

The extant literature acknowledges the positive influence of SCRM on operational performance in multiple ways, for example, by mitigating uncertainty [15], preventing disruptions [35], increasing responsiveness [69], lowering errors and failures [15], and allowing an appropriate reaction to the external environment [2]. Much of this coincides with agility performance. From the information processing viewpoint, SCRM relies on gathering and processing various forms of supply chain information, including information on logistics, inventory, quantity, quality, market, and technology [2]. This information can enable successful product development and modifications [70], production and delivery reliability [61], forecast improvement [71], and responsiveness toward volume and mix variations [61]. As such, high information exchange and coordination with supply chain partners are based on a greater appreciation of mutual interests [72]. This appreciation leads to more focused efforts in responding to market needs [61], which is essentially what the agility performance metrics gauge. Hence, by linking SCRM with the information processing capability, we expect the following:

H5: SCRM effectiveness is positively associated with agility performance.

G. Mediation Effects

The view of organizations as information processing entities links uncertainty, information flow, and organizational performance (see Fig. 1). Uncertainty in this perspective implies the gap between the information required and the information possessed to operate [29]. We have discussed the role of conducive organizational settings and technological bases in building information processing capacity and filling the information gap in an uncertain and challenging environment. The information processing view is congruent with the understanding that because a challenging business environment increases uncertainty and supply chain risks [8], [35], the management of risks can be facilitated by improved information flow through better organizational and technological contexts. Considering the arguments for H1–H4, we hypothesize the following mediations:

TABLE I
SAMPLE DEMOGRAPHICS

	No.	%
Firm size (Number of employees)		
1. Small companies (Up to 250)	219	67.4
2. Medium companies (251–500)	50	15.4
3. Large companies (More than 500)	56	17.2
Industrial Sector		
1. ISIC 25 Manufacturer fabricated metal products	106	32.6
2. ISIC 26 Manufacturer of the electronic computer and optical products	40	12.3
3. ISIC 27 Manufacturer of electrical equipment	50	15.4
4. ISIC 28 Manufacturer of equipment and machinery not elsewhere classified	92	28.3
5. ISIC 29 Manufacturer of trailers, motor vehicles, and semitrailers	19	5.9
6. ISIC 30 Manufacturer of other transport equipment	18	5.5
Regions		
1. Europe	152	46.77
2. North America	30	9.23
3. China	62	19.08
4. India	43	13.23
5. Asia (other)	31	9.54
6. South America	7	2.15

H6: An enhanced organizational context mediates the relationship between environmental context and SCRM effectiveness.

H7: An enhanced technological context mediates the relationship between environmental context and SCRM effectiveness.

We have also argued that environmental challenges necessitate appropriate organizational and technological contexts to improve SCRM effectiveness (H3 and H4) and, consequently, agility performance (H5). Hence, our final set of hypotheses is as follows:

H8: SCRM effectiveness mediates the relationship between organizational context and agility performance.

H9: SCRM effectiveness mediates the relationship between technological context and agility performance.

III. METHOD

Data from the most recent edition of the International Manufacturing Strategy Survey (IMSS VI) was used to validate the hypothesized model. The survey was developed by a large academic research group to measure the performance of manufacturing firms along with their strategies and practices. IMSS focuses on manufacturing firms in various industries such as machinery, electronics, metal production, transport equipment, and the motor vehicle industry that belong to ISIC codes 25 to 30.

In the current edition, 7167 firms were selected across the globe, and a total of 931 surveys were collected from 22 countries. To serve the purpose of our research questions, we filtered the data of firms operating with a single plant. After filtering, a total of 325 usable responses were screened (see Table I). The original questionnaire was produced in English and then translated by national researchers in countries where English was not the first language. The managers' active involvement ensured the instrument's relevance and content validity. Data were collected from all the surveyed countries by deploying a standard methodology. The respondents were the employees connected to the operations decisions of the organization (operations managers, supply chain managers, plant managers, etc.). Potential respondents were contacted through the local research team of the country, and questionnaires were sent to the organizations through fax, email, or ordinary mail.

IMSS questionnaire was based on a self-respondent and self-reported survey that can lead to the common method bias and hinder the validity of the analysis [73]. This issue was countered through some procedural measures. First, the IMSS questionnaire had built-in features to minimize common method bias [74]. The items used to measure the constructs were clubbed into different questionnaire sections. The constructs in our study included varying numbers of items (ranging from 2 to 6) and were measured by different scales of comparisons and levels of implementation [75]. Second, the data collection process of IMSS helped control for common method bias. The respondent's anonymity was ensured in data collection, which encouraged the respondent to complete the questionnaire objectively [76]. Third, we used the respondent's tenure as a variance marker variable, measured on a single-item scale [43], [74]. The respondent's tenure as a measure of experience and work length was theoretically unrelated to other constructs in this study. The insignificant correlations between marker variables and other constructs indicated the absence of common method bias [73], [74].

A. Measures

The constructs used in the study were measured as reflective constructs using multiple items from the IMSS survey except for the environmental context, which was operationalized as a composite indicator. The environmental context was operationalized by the rate of technological change, bargaining power of customers, competitive rivalry, and the threat of substitute products [48], [52]. These indicators collectively affect or shape the environmental context [77]. Constructs used in this study are summarized in Appendix. Firm size and industry types were controlled to ensure contextual validity; both may affect the firm's behavior toward risk management and performance [5]. We operationalized firm size as a logarithmic value of the total number of employees in the business unit. Considering that a firm's risk exposure depends on the type of industry [38], ISIC code classification was used to operationalize industry type as a categorical variable [5].

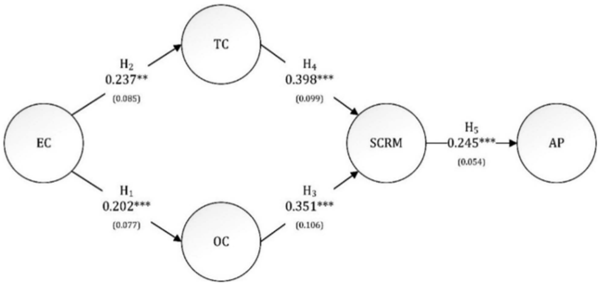
B. Measurement Model Testing

The validities and reliabilities of the constructs were examined using a measurement model, followed by structural model testing [78]. We conducted confirmatory factor analysis (CFA) of all constructs. The result provided a good fitting model ($\chi^2_{(175)} = 290.308$, CMIN/df = 1.659, GFI = 0.918, AGFI = 0.892, CFI = 0.961, RMSEA = 0.045, SRMR = 0.048). All the values of fit indices were within the acceptable range [79]. The Appendix shows measurement model analysis results. Agility performance was measured as second-order constructs, requiring an examination for appropriateness [80]. First, the hypothesized model was compared with the model in which agility performance was operationalized as multiple first-order constructs (quality, design, delivery, and flexibility). Fit indices of the model with first-order operationalization of agility performance ($\chi^2_{(161)} = 450.243$, CMIN/df = 2.654, GFI = 0.785, AGFI = 0.723, CFI = 0.823, RMSEA = 0.060, SRMR = 0.061) were inferior to the original hypothesized model; thus, it was appropriate to operationalize agility performance as second-order constructs. Additionally, factor loadings of all first-order constructs on their second-order constructs were significant (p-value < 0.01), thus supporting the appropriateness of agility performance as second-order constructs.

TABLE II
RESULTS OF CORRELATION ANALYSIS

	EC	**OC**	**TC**	**SCRM**	**AP**
Environmental Context (**EC**)	--				
Organizational Context (**OC**)	0.176**	**0.644**			
Technological Context (**TC**)	0.202**	0.517**	**0.752**		
Supply Chain Risk Management (**SCRM**)	0.161**	0.507**	0.518**	**0.730**	
Agility Performance (**AP**)	0.075	0.387**	0.334**	0.400**	**0.781**

Bold values are the square root of AVE. significance established at p-value < 0.001 (two-tailed).



*p < 0.05; **p < 0.01; ***p < 0.001 (**EC**: Environmental Context; **OC**: Organizational Context; **TC**: Technological Context; **SCRM**: Supply Chain Risk Management; **AP**: Agility Performance.)

Fig. 3. Hypothesis testing results—Standard path coefficients (standard errors).

Standardized item loadings in all constructs were above the desired limit (0.60) [81]. Likewise, the values for Cronbach's alpha for all constructs were higher than 0.60, thus satisfying internal consistency and construct reliability [82]. The AVE of all variables was higher than 0.50 (except for organizational context, AVE = 0.416), thus satisfying the condition of convergent validity [83]. We checked discriminant validity by comparing the square roots of AVE for each construct and off-diagonal correlation measures in Table II. The greater value of the square roots of AVE from off-diagonal correlation measures supports discriminant validity [84]. In addition, we tested for discriminant validity by comparing chi-square values of constrained and unconstrained models. In the unconstrained model, the correlation between each pair of constructs was set equal to 1. The values of chi-square difference were significant (p-value < 0.05) in each pair of constrained and unconstrained models, thus giving additional evidence of discriminant validity [85].

C. Hypothesis Testing

The hypothesized model was tested using SEM with maximum likelihood estimation in AMOS version 22. The fit indices revealed a good fitting model ($\chi^2_{(174)} = 272.561$, CMIN/df = 1.566, GFI = 0.925, AGFI = 0.900, CFI = 0.967, RMSEA = 0.042, SRMR = 0.039).

As shown in Fig. 3, there was a positive relationship between environmental and organizational contexts (H1: $\beta = 0.202$,

TABLE III
BOOTSTRAP RESULTS FOR DIRECT, INDIRECT, AND TOTAL EFFECTS

Hypotheses	IV	MV	DV	IV → MV	MV→ DV	IV → DV	IV → MV → DV Indirect Effect	IV → MV → DV Total Effect	95% confidence interval
H_6	EC	OC	SCRM	0.202**	0.351***	0.010	0.119***	0.175**	0.043–0.230
H_7	EC	TC	SCRM	0.237***	0.398***	0.010	0.151**	0.175**	0.065–0.278
H_8	OC	SCRM	AP	0.351***	0.245*	0.253**	0.086**	0.339***	0.013–0.156
H_9	TC	SCRM	AP	0.398***	0.245*	0.129	0.097**	0.226*	0.012–0.019

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ | **EC**: Environmental context; **OC**: Organizational context; **TC**: Technological context; **SCRM**: Supply chain risk management; **AP**: Agility performance.

TABLE IV
CONTEXTUAL ANALYSIS OF HYPOTHESIZED MODEL

Hypo-theses	Path	Aggregate Effect	Firm Size		Countries		Regions	
			Small (212)	Medium/ Large (113)	Developing (118)	Developed (207)	European/ North American (182)	Asian/ South American (143)
H_1	EC→OC	0.202**	0.219*	0.218**	0.225*	0.191*	0.192**	0.177**
H_2	EC→TC	0.237***	0.244**	0.245***	0.285**	0.215**	0.221**	0.266***
H_3	OC→SCRM	0.351***	0.510***	0.492***	0.433***	0.404***	0.436***	0.328***
H_4	TC→SCRM	0.398***	0.272*	0.292**	0.402***	0.440***	0.358***	0.514***
H_5	SCRM→AP	0.245*	0.290*	0.259*	0.214**	0.514***	0.523***	0.18*
H_6	EC→OC→SCRM	0.119***	0.099**	0.124**	0.106**	0.132***	0.111**	0.125***
H_7	EC→TC→SCRM	0.151**	0.148***	0.152***	0.146***	0.159**	0.143**	0.156**
H_8	OC→SCRM→AP	0.086**	0.128**	0.039	0.049	0.207***	0.190**	0.042
H_9	TC→SCRM→AP	0.097**	0.109**	0.071**	0.048*	0.206***	0.217**	0.040*

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$ | **EC**: Environmental context; **OC**: Organizational context; **TC**: Technological context; **SCRM**: Supply chain risk management; **AP**: Agility performance.

p-value < 0.001), and environmental and technological contexts (H2: $\beta = 0.237$, p-value < 0.01). Organizational and technological contexts significantly affected SCRM. The higher the technology implementation level was, the higher the effectiveness of SCRM was found (H4: $\beta = 0.398$, p-value < 0.001). Similarly, the more conducive the organizational context was, the higher the effectiveness of SCRM was found (H3: $\beta = 0.351$, p-value < 0.001). Furthermore, SCRM had a significantly positive effect on agility performance (H5: $\beta = 0.245$, p-value < 0.001). The results provided support for all direct hypotheses.

1) Mediation Effects: We tested for mediation effects to investigate further the relationships between the constructs in our hypothesized model. The three most commonly used mediation detection methods are user-defined estimand, Sobel test, and phantom variable-based approach [86]. We employed a bootstrapping-based user-defined estimand approach. It is considered more robust than normality assumptions, appropriate for maintaining reasonable type I error in large samples, and convenient to apply in SEM [87].

> Bootstrapping is a non-parametric statistical procedure in which the data set is repeatedly sampled, and indirect effects are calculated. These indirect effects are then tested for significance using confidence intervals. If indirect effects are significant, mediation is inferred in the model. [17]

Bootstrapping was preferred over the Sobel test or other methods of mediating testing because of its robustness and multiple iterations executed on the sample [88]. The bias-corrected bootstrapping procedure was used with 5000 resamples to assess the size and significance of indirect effects. Apart from *p-value* < 0.05, a nonzero value of upper and lower confidence intervals indicated the significance of indirect effects.

Table III shows that organizational and technological contexts fully mediated the relationship between environmental context and SCRM (H6 and H7, respectively). This mediation suggests that firms employed technological and organizational factors to enhance their risk management capabilities under a challenging environment. The test also revealed a partial mediation of SCRM between organizational context and agility, and a full mediation of SCRM between technological context and agility.

2) Robustness Check: We followed the approach used by Gillani et al. [31] to test the empirical robustness of the hypothesized model. We segregated the sample into three groups, i.e., small ($\leq$250 employees) versus medium/large firms ($>$250 employees), developed versus underdeveloped countries, and Asian/South American firms versus European/North American firms. As shown in Table IV, all hypotheses remain significant across different firm sizes, developing versus developed countries, and different regions, except for H8. For medium/large firms, developing country context, and firms from Asian and South American regions, the mediating role of SCRM in the organizational context and agility performance relationship was insignificant. One possible reason for this could be that in small firms and developing country context, the sophistication of SCRM practices was low [89].

Although we have relied on strong theoretical arguments to support the suggested causalities between the constructs of the TOE framework, an empirical analysis was imperative to ensure the validity of the path analysis of the hypothesized model and the absence of reverse causalities. We have argued that changes in the environmental context will lead manufacturers to enhance their technological context in terms of new product development, improved communication technologies, and the deployment of technological tools and techniques [31]. Similarly, environmental challenges will trigger strategic changes in the organizational context, such as delegation, open communication, flexible and fluid structures, and greater autonomy for the work teams [60]. On the contrary, it may be argued that firms' technological and organizational readiness is imperative in challenging environments, i.e., firms with more robust technological and organizational capabilities will be in a better position to cope with environmental uncertainties. To check for this issue of reverse causality, we conducted Durbin–Wu–Hausman augmented regression suggested by Davidson and Mackinnon [90] and deployed by various studies [2], [91]. We used supply chain uncertainty as an instrumental variable as it is correlated with environmental context [92] but not with organizational and technological contexts. Supply chain uncertainty was measured on a three-item scale focusing on fluctuations in demand, frequent changes in supply requirements, and frequent modifications in the supplied components [93]. We conducted a stage 1 regression analysis with environmental context as a dependent variable and predicted the residual of the stage 1 model. In the stage 2 model, we include the residual with technological and organizational contexts as dependent variables. The beta-coefficients of the residual in the second stage were insignificant for technological ($\beta = 0.0169$, $p > 0.05$) and organizational contexts ($\beta = 0.0189$, $p > 0.05$). These results indicated that the bias of reverse causality was not a serious issue.

IV. DISCUSSION

Integrating the elements of IPT and the TOE framework, this study conceptualizes SCRM as a capability that leads to agility while being underpinned by organizational and technological contexts. The investigation focuses on the proposition that enhancing organizational and technological contexts in response to a challenging environment improves SCRM effectiveness and agility (see Figs. 1 and 2). The support for this proposition is found through broad-based empirical data and serves to synthesize the currently fragmented and inconsistent understanding of the organizational and technological antecedents of SCRM. Sections IV-A–IV-C discuss the findings and conceptualization in relation to the earlier studies, and Section IV-D highlights the managerial implications.

A. Impact of Environmental Context on Organizational and Technological Contexts

Organizations' response to external threats is a highly deliberated and unresolved subject in the literature with two contradicting views. One of the views suggests that external threats increase the organizational tendency to change, decentralize, and become flexible [32], [50], [51]. The threat-rigidity thesis, on the contrary, posits that organizations become inflexible, conventional, and restrictive in communication when faced with external threats. Although both views have been widely discussed in the literature [12], the arguments are surprisingly underdeveloped empirically [57]. The findings in this article indicate a positive association between the environmental challenge and the extent of flexibility, collaboration, and integrative and communication technology use in organizations. Backed by IPT and DCV, these findings align with the view suggesting greater flexibility and freer communication flow through enhanced organizational and technological contexts in response to external challenges [5], [11]—the dominant view in the scholarship [57]. Employing IPT and the TOE framework, this study also provides a distinct viewpoint to understand the association between environment and technology adoption, which has been predominantly captured through combinatorial technology evolution theory [31].

B. Contextual Aspects in the Information Processing View of SCRM

SCRM has been viewed as a dynamic capability for driving firm performance [94] and an information-intensive process that is highly reliant on the timely acquisition and utilization of relevant information [2], [11], [15]. Our study extends the information processing viewpoint of SCRM by suggesting a positive role of organizational and technological contexts in information availability, information processing, and, consequently, in the effectiveness of SCRM. Although previous studies have explored the link between information-related practices and SCRM [95], holistic information processes and the baseline infrastructure required for information processing capability have not received much attention. The extant studies mainly argue a positive role of supply chain integration in facilitating information acquisition and utilization for managing risks. For example, Kauppi et al. [1], Munir et al. [2], and Shou et al. [43] suggest a positive role of internal and external integration in the acquisition and processing of information and, thus, in supporting SCRM and improving performance. Jat et al. [95] suggest a positive role of lateral relations with customers in enhancing information processing capability and SCRM. Fan et al. [15] investigate different organizational factors in relation to the risk information processing system but the factors they study are specific to SCRM culture, team, and strategy. We contribute to SCRM literature and IPT by explicitly considering organizational and technological contexts and arguing in support of their underlying role in bridging the information gap to handle uncertainty and risks. Our study, on a more fundamental level, complements the earlier empirical works that positively link integration and SCRM through the information processing lens [2], [43]. Integration can be considered a socio-technical phenomenon resulting from the interplay of a range of factors, including technical aspects and soft elements belonging to the organization and employees of a firm [10].

C. Impact of Organizational and Technological Contexts on SCRM and Agility

Supply chains' ability to cope with risks has been conceptually linked to both organizational (human) and physical (technological) resources with a call for empirical validation [13], [23]. Analyzing the impact of organizational and technological contexts on SCRM based on a global and cross-industry survey, our study provides an empirical generalization of the role of human and physical enhancers of SCRM.

In broader SCRM literature, studies have provided somewhat mixed arguments regarding the relationship between organizational factors and performance. On the one hand, it is suggested that the measures that facilitate cooperation among internal functions lead to effective risk management and improved operational performance [2]. Integrated firms are considered more responsive to environmental changes and customer demand [96], and integration is considered a requirement for risk management assets to achieve their objectives [41]. Inclusive decision-making is regarded as a containment measure for circumstances that aggravate risks [41]. Many risk management frameworks also include the aspects of improvements [8]. Continuous improvement is considered a means of lowering disruptions caused by quality and delivery-related problems [34]. On the other hand, it is highlighted that the initiatives taken for efficiency can increase the risk factor and deteriorate performance. For example, even though lean practices are linked to improved performance on a wide range of matrices, Hallgren and Olhager [66], Tang and Musa [4], and Kauppi et al. [1] argue that these practices result in supply chains being more fragile to disruptions because of less cushioning. Similarly, studies have suggested that integrative settings increase complexity and exposure to risk [22], reduce flexibility [21], and do not necessarily lead to improved performance [97]. Tight coupling and system complexity can lead to negative outcomes in accidents [2]. The inconsistencies in the empirical literature may have resulted due to the focus on SCRM strategies, such as integration, rather than SCRM enablers [9]. Our study suggests a positive role of organizational settings conducive to collaboration and information sharing in enabling SCRM and improving performance. Confirming a partial mediation effect of SCRM effectiveness in the relationship between organizational context and agility performance, the findings suggest a direct positive impact of collaborative and flexible settings on agility performance, which is further strengthened by SCRM effectiveness. These findings complement the results of Munir et al. [2], showing a partial mediation of SCRM between integration and operational performance.

While the research on the association between an organization's technological context and SCRM is not well-developed [18], [23], it is argued that technology inductions can potentially increase risks and deteriorate performance by raising complexity [23]. Technology can affect traditional boundaries and require reorganization of value creation processes, change the nature of work and, hence, cause disruptions. However, the use of technology in manufacturing can improve the effectiveness of risk management through, for example, better tracking [96], better synchronization with suppliers, and quick alerts about process glitches [18]. This study complements the empirical results of Gillani et al. [31], showing a positive impact of technological context on operational performance. However, rather than showing a direct association, the results in this study suggest a positive association between technological context and agility performance through SCRM effectiveness.

Several studies have suggested the benefits of implementing SCRM on performance as it reduces disruptions and their impact [35], [69], [98]. The widely reported SCRM approaches include maintaining excess inventories, a larger number of suppliers, and extra capacity—all requiring additional costs and upfront investment [1], [2]. These approaches, which arguably allow a reduction in information processing needs, can potentially weaken firm performance when the environment is highly uncertain and necessitates a high level of buffering. It is also suggested that strong SCRM requires mechanistic controls, i.e., formal and deliberately installed structures, to attain specific and structured information for decision-making, strategy development, and problem-solving [16]. However, mechanistic setups can become exhausted in an uncertain and challenging environment. Overall, our findings support the proposition that informal and flexible arrangements, through the setup of conducive organizational and technological contexts, can improve information processing capability, the effectiveness of SCRM, and agility.

D. Managerial Implications

For supply chain managers, this study generates important insights into the underlying mechanisms for effective and efficient risk management. It suggests adopting the information processing perspective for SCRM, arguing that information processing capability is fundamental for managing uncertainty and strengthening SCRM. To enhance this core capability for SCRM, the findings of this research indicate that manufacturing managers should focus and invest in organizational and technological contexts. The conventional approaches to managing risks include maintaining excess resources (shock absorbers) and deploying mechanistic management systems for problem solving. These approaches reduce the requirement for information or its processing; however, in a highly uncertain situation, the former can have high costs while the latter can be overwhelmed. For example, when demand or supply is highly uncertain, a manufacturer can maintain a high excess capacity and stocks to absorb demand and supply shocks. These reserves will relieve the manufacturer from extensive information processing to avoid disruptions but the associated cost will be high. In a formal mechanistic system, exceptional scenarios or disruptive instances will be referred to the management for resolution and problem solving. The mechanistic approach will also reduce the information needed in the manufacturer's organizational structure as the information processing is centralized but the managers will be overwhelmed under a large number of exceptional scenarios. To avoid these undesirable conditions in managing uncertainty and risks, managers should enhance information processing capabilities through conducive organizational settings along with communication and integrative technologies.

By efficiently bridging the information gap, strong technological and organizational contexts can influence the ability to read signals and precursors of undesirable events, enable shared understanding, and facilitate responsive counteractions. Such enhancements can also support other SCRM strategies like internal and external integration, which rely on organizational and technological underpinnings. A strong technological context, in particular, can enable the implementation of more advanced technologies with a greater impact on SCRM.

Our study also provides a timely inquiry into the role of organizational and technological contexts in manufacturing as businesses plan their transition from the pandemic era. Even though there is a lack of clarity on the future of work settings, a general impression is that work structures will change significantly while supply chain challenges will persist. Hence, understanding the implications of organizational and technological factors on SCRM and performance is timely and important.

V. CONCLUSION

This study offers several important contributions and novel insights by extending the information processing perspective of risk management, which is a highly relevant lens for studying SCRM and merits more attention in the literature [2], [15]. The study, backed with rich theoretical arguments and strong empirical evidence, highlights the pivotal role of information in the effectiveness of SCRM [15], [40] and the importance of technological and organizational contexts in the information processing mechanism.

The study contributes to the literature in four major ways. First, the study argues that environmental challenges raise information processing needs while organizational and technological contexts influence information processing capabilities and, therefore, the effectiveness of SCRM. This perspective extends the information processing viewpoint in the extant SCRM literature, which has focused mainly on integration. It is argued that SCRM strategies like integration rely on organizational and technological factors [10]. Hence, focusing on the organizational and technological contexts for effective SCRM is fundamental. Second, the study provides a synthesis of IPT with the TOE framework. By employing the TOE framework to understand the impact of manufacturing contexts on SCRM, the study extends the conventional conceptualization of the framework, which has been limited to the technology and innovation management domain [28], [31]. The extension demonstrates the framework's versatility and should motivate its use in research on other supply chain management domains. Third, supported by IPT, the empirical findings in this study suggest that organizations respond to external challenges through collaborative and flexible work organization, enhanced technological setup, and higher information flow. This is in contrast to the threat-rigidity thesis [56]. Previous studies have aligned with both threat-rigidity and its counter view but, as discussed in Section IV-A, the support has been predominantly conceptual. Our study is an important contribution in this debate as it employs a large-scale international survey. Fourth, the findings indicate a positive role of flexible and collaborative organizational settings and enhanced technological setups in improving SCRM effectiveness and agility performance. As discussed in Section IV-C, the extant SCRM literature presents mixed arguments on these relationships considering narrow organizational factors and specialized technologies. The findings in this study address the inconsistencies in the literature through broad-based empirical model and evidence.

VI. LIMITATIONS AND SCORE FOR FUTURE RESEARCH

The model and findings of this study indicate some important avenues for further research. One of the directions can be to explore the interrelations between the contexts and different dimensions of risk management. For example, future studies can investigate whether there is an association between technological and organizational contexts, whether technological and organizational contexts sequentially impact risk management, and whether the contexts have different associations with the preventive and reactive dimensions of risk management. Even though we have argued that a challenging environment leads to enhanced organizational and technological contexts without finding reverse causality concerns in the analysis, inverse relationships are also plausible. It can be argued that organizationally and technologically advanced organizations opt for challenging business environments. Future studies can seek theoretical and empirical support in this direction.

A limitation of this work is the scope of the contexts. The technological and organizational contexts in this study are considered internal to an organization. Even though measures internal to an organization act as a foundation for the effectiveness of the external measures, and hence, our inquiry provides valuable insights, SCRM is an interorganizational phenomenon. Considering technological and organizational contexts on the supply chain level can provide more credence. Also, this study only considers firms that operate with a single plant. The scope of the study can be broadened to cater to multiplant operations.

Finally, considering risk classification may also address the inconsistencies around the threat-rigidity thesis. Scholarship on threat-rigidity thesis refers to abrupt and substantial threats. It can be insightful to investigate if organizations respond to abrupt and substantial threats with rigidity while sustained challenges from the environment increase their flexibility.

APPENDIX
CONSTRUCT MEASUREMENT, VALIDITY, AND RELIABILITY ANALYSIS

Measurement Item		**Factor loadings**
Technological Context (Cronbach α = 0.799, AVE = 0.566) | Literature: [31], [99], [100]		
1	Technological integration between product development and manufacturing through, e.g., CAD-CAM, CAPP, CAE, Product Lifecycle Management	0.750
2	Integrating tools and techniques, such as Failure Mode and Effect Analysis, Quality Function Deployment, and Rapid Prototyping	0.754
3	Communication technologies, such as teleconferencing, web-meetings, intranet, and social media	0.638
Organizational Context (Cronbach α = 0.828, AVE = 0.416) | Literature: [31], [50], [51], [101]		
1	Delegation and knowledge of your workers (e.g., empowerment, training, encouraging solutions to work-related problems, pay for competence or incentives for improvement results)	0.600
2	Open communication between workers and managers (information sharing, encouraging bottom-up open communication, two-way communication flows)	0.533
3	Lean organization (e.g., few hierarchical levels and a broad span of control)	0.498
4	Continuous improvement programs through systematic initiatives (e.g., kaizen, improvement teams, improvement incentives)	0.566
5	Autonomous teams (e.g., team responsible for planning, execution, and control, workers sharing experience, knowledge, and skills, formalization of team composition and responsibilities, workgroup incentives)	0.605
6	Workers' flexibility (e.g., multitasking, multiskilling, job rotation)	0.420[a]
7	Use of flexible forms of work (e.g., temporary workers, part-time, job sharing, variable working hours)	0.271[a]
Environment Context (Composite indicator) | Literature: [31], [48], [52]		
1	The rate of technological change	
2	Competitive rivalry	
3	The threat of product substitute	
4	Bargaining power of customers	
Supply Chain Risk Management (Cronbach α = 0.875, AVE = 0.534) | Literature: [2], [34], [102]		
1	Preventing operations risk (e.g., select a more reliable supplier, use clear safety procedures, preventive maintenance)	0.670
2	Detecting operations risks (e.g., internal or supplier monitoring, inspection, tracking)	0.777
3	Responding to operations risks (e.g., backup suppliers, extra capacity, alternative transportation modes)	0.754
4	Recovering from operations risks (e.g., task forces, contingency plans, clear responsibility)	0.717
Agility Performance – Second-Order Construct (Cronbach α = 0.768, AVE = 0.611) | Literature: [5], [66], [103], [104]		
1	Quality performance	0.844
2	Design performance	0.829
3	Delivery performance	0.671
4	Flexibility performance	0.772
Quality performance (Cronbach α = 0.834, AVE = 0.857)		
1	Product quality	0.926
2	Conformance quality	0.926
Design performance (Cronbach α = 0.620, AVE = 0.726)		
1	New product introduction ability	0.852
2	Product customization ability	0.852
Delivery performance (Cronbach α = 0.821, AVE = 0.850)		
1	Delivery speed	0.922
2	Delivery reliability	0.922
Flexibility performance (Cronbach α = 0.771, AVE = 0.814)		
1	Mix flexibility	0.902
2	Volume flexibility	0.902

AVE: Average Variance Extracted; [a] Items dropped due to low factor loadings

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