A Risk Mitigation Deficit Measure to Control Risks in Supply Chains: An SMEs Perspective

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Abstract

The misalignment between the external risks a company faces, such as natural disasters or macroeconomic shocks, and the supply chain risk mitigation efforts it undertakes has received limited attention, particularly from the perspective of small and medium-sized enterprises (SMEs). Using contingency theory as a theoretical underpinning, this research introduces a novel fit measure, the risk mitigation deficit (RMD), to capture this misalignment. It then examines the impact of RMD on operational risk (OR), which refers to the failure of the supply chain to achieve key objectives such as cost efficiency, quality, and sustainability. SMEs face unique challenges, as risk mitigation efforts are resource-intensive, requiring careful alignment of mitigation measures with risk exposure. This study contributes by analyzing data from 213 SMEs in the Spanish agri-food supply chain. The results suggest that both upstream and in-house RMD positively influence output OR, while downstream RMD shows no such relationship. Similarly, upstream RMD does not appear to influence input OR. A robustness test examining the effect of mere risk mitigation effort (RME) on OR confirmed that RMD possesses explanatory power over OR that RME alone does not. These findings underscore that a one-size-fits-all approach to supply chain risk management (SCRM) is ineffective, especially for resource-constrained SMEs. Instead, tailored, context-specific solutions are needed to help SMEs efficiently balance risk profiles and mitigation efforts.

Keywords: supply chain risk management, fit analysis, profile deviation, risk assessment, risk mitigation

Managerial relevance statement

Engineering managers often play a leading role in product and service development as well as in technical projects. In very small companies, this role frequently even encompasses supply chain management. By introducing a novel risk mitigation deficit measure, this study provides engineering managers with an easy-to-use tool to communicate with supply chain managers or to improve their own supply chain decisions when they are responsible, thereby optimizing the allocation of scarce resources in SMEs. The study also offers valuable insights for policymakers. Public policy interventions are critical to supply chain risk mitigation, and it is well established that SMEs often require interventions tailored to their specific needs. The proposed framework is quick and easy to apply, helping policymakers both to survey the SME landscape and structure their interactions with individual firms. This paper also contributes to the following SDGs: SDG 8, and SDG 1.

I. **Introduction**

In recent decades, extreme and unforeseen events—such as the terrorist attacks on the World Trade Center in 2001, the 2008 financial crisis, and the global COVID-19 pandemic—have intensified businesses' attention to the importance of supply chain risk management (SCRM). At the same time, greater reliance on global supply chains has made managing such risks increasingly complex and expensive, prompting significant growth in SCRM research and practice [1]–[3]. Managing supply chain risk is especially challenging for small and medium-sized enterprises (SMEs). Not only are SMEs more vulnerable to various types of shocks, including supply chain disruptions, than larger companies [4], but they also lack the substantial resources and capabilities required to invest in and implement complex supply chain risk mitigation initiatives [4], [5]. For this reason, it is important to conduct research that helps SMEs optimize their investments in risk mitigation. However, current literature on SCRM focuses primarily on larger firms [6], leaving the impacts on SMEs' mitigation efforts relatively underexplored.

Another relatively overlooked aspect of SCRM relates to fit perspectives. According to the contingency theory perspective [7], there is no one-size-fits-all approach, and effective practices depend on contextual factors. This view has been widely applied across various management fields, including supply chain management. In this context, the implication is that there is no single best risk management strategy. Rather, the optimal strategy varies depending on specific contingencies of each company. Contingency analysis or fit analysis can take several forms, such as moderation effects, mediation effects, and fit to an ideal profile [8], each offering different insights. Profile adjustment enables the inclusion of a wider range of variables in the analysis, which is useful for reflecting the context of SMEs. However, this type of analysis has been relatively underexplored, with a few exceptions [9]–[13] and has yet to adopt a disaggregated approach that examines upstream and downstream SCRM separately. Disaggregation could offer new opportunities for optimizing SCRM that have not yet been explored in the operations and supply chain management research. Additionally, broadening this research niche with diverse performance variables and large-sample quantitative analyses could enhance our understanding of profile-based SCRM fit analysis.

In order to address the aforementioned gaps in the existing SCRM literature, we introduce a novel fit framework, risk mitigation deficit (RMD). This concept builds on the notion of fit to an ideal profile and captures the misalignment between the level of external risk (ER), such as macroeconomic shocks or sanitary crises [12], [14]–[16], and SMEs' risk mitigation efforts (RME). We operationalize RMD in three different areas of the supply chain: upstream, in-house, and downstream. We then investigate each RMD in relation to the likelihood that the supply chain would fail to meet its operational objectives, such as cost, quality, and sustainability in both its inputs (e.g., raw materials) and its outputs (products and services). For the purposes of this study, the former will be referred to as input operational risk (OR), and the latter as output OR.

Using survey data from 213 Spanish SMEs in the agri-food supply chain, collected in 2021, during the COVID-19 pandemic, we take this unique opportunity to examine the impact of RMD on ORs in a relatively controlled manner. The results indicate a significant link between an SME's output OR and its RMD, both upstream and in-house. However, no significant relationship was found with downstream RMD. Additionally, no significant relationship was found between an SMEs' input OR and upstream RMD. Furthermore, we found a significant positive relationship between input OR and output OR.

These findings help address the previously identified gaps in the SCRM literature. First, we extend the limited body of research on SCRM in SMEs by providing theoretical explanations and empirical evidence for the need for a more targeted approach to supply chain risk mitigation. Second, we contribute to the literature by advancing a contingent perspective on SCRM through the introduction of a deviation-from-ideal-profile measure of mitigation deficit, which, when applied across different areas of the supply chain, enables SMEs to allocate scarce resources more efficiently.

II. Literature Review

A. Supply Chain Risk, Disruptions, and SMEs

Supply chain risk is the likelihood of events that will lead to adverse outcomes in the supply chain [1], [17], [18]; it has also been referred to as *supply chain disruption* [19]. The notion of supply chain risk, or disruption, includes both events that represent the source of the risk and adverse outcomes that are the consequences of such events [19].

Accordingly, we note different proposals for categories of the sources of risk. For example, some authors have classified them into natural catastrophes (i.e., hurricanes, tsunamis, Bird Flu, pandemics) and man-made catastrophes (i.e., terrorist attacks, accidents, economic downturns) [20]. Other authors differentiate external risks versus internal risks [21]–[24] and have also broken down the causes into macro-level risks (external events such as earthquakes, weather-related disasters, wars, terrorism, political instability) and micro-level risks (events caused by partners in the supply chain, or internal events caused by the companies themselves) [2]. In this work we focus on macro-level external risk [2], both natural and man-made [20]. Which we refer to as external risk (ER). In accordance with the aforementioned categories, our study includes the following levels: political, economic, sociological, technological, natural, and health crisis. These six external risks are consistent with the well-known PESTEL analysis, facilitating the implementation of the proposed measure by practitioners.

Similarly, we note some general categories of the consequences of supply chain risk, namely, financial, valuation, or operational [25]–[28], which vary greatly [29], [30]. Generally, supply chain challenges lead to financial distress, manifested as short-term profit loss [25] or long-term decreases in firm valuation [26]. They also bring about various operational challenges, including increased costs and lead times [27], [31]. In this study, we capture the consequences-based perspective of supply chain risk from an operational point of view and in two ways: by considering the input side and the output side of the supply chain separately. We refer to the former as input operational risk (OR) and to the latter as output OR.

As highlighted by the literature, small firms, compared with their larger counterparts, are more susceptible to the above-described shocks [4] [32]. The disproportionate impact on SMEs was clearly demonstrated during the COVID-19 pandemic, when a higher percentage of SMEs experienced supply chain disruptions compared with larger firms [6], and many of them struggled to survive. Such increased exposure to supply chain risks and disruptions stems from several causes. The most obvious is that SMEs lack the resources and capabilities [5], [33], [34] to manage supply chain risks systematically [4], [35]. Such factors emphasize the need for dedicated research that takes SMEs' perspectives. However, as noted, current research on supply chain risk and disruptions predominantly focuses on large companies, leaving a gap with regard to understanding how SMEs navigate these challenges [6].

B. Supply Chain Risk Mitigation Strategies

Supply chain mitigation has been identified by both academic literature [1], [2], [36]–[38] and industry practices (e.g., ISO 9001) as a key SCRM process, which typically occurs after firms identify emerging supply chain–related uncertainties and evaluate their likelihood and severity [39]. This mitigation may entail different strategies [20], [27],[40]- [48] which can be succinctly described in terms of the common mechanisms they activate. For instance, some strategies introduce incentives or penalties for customers or suppliers, thereby activating a risk-sharing mechanism [27]. Others rely on redundancy or absorption mechanisms, such as duplicating capacity along the chain or maintaining strategic stock; these have often been labeled as *buffering strategies* in the literature [43], [44]. Finally, some emphasize collaborative mechanisms with partners to design joint mitigation solutions [46], [47], which are commonly referred to as *bridging strategies* [43]- [44]. Each company selects the combination of strategies that best fits its specific context, since many of them can complement one another. In general terms these strategies help mitigate external risk by addressing firms' dependence on supply chain components (suppliers, customers, or in-house facilities) [44]. As the purpose of this paper is to analyze how deficits in the application of these strategies across different parts of the supply chain affect operational risks—both in inputs and outputs—the strategies will be presented according to the supply chain area in which they apply: upstream, in-house, and downstream.

However, SMEs, struggle with such efforts [4], [6], reflecting their general tendency to be under-resourced in terms of skills and resources. This lack of resources hinders SMEs' efforts to create buffers (e.g., redundant inventory, additional capacity, multiple suppliers) and then manage them, because such efforts demand significant resource investments and high-level operational skills [43]. The successful implementation of a bridging strategy, through collaborative engagement with supply chain partners, also imposes coordination costs [44]. Furthermore, collaborative engagement often is complicated by power imbalances between SMEs and their larger partners, such that dominant large firms can use their power to coerce SMEs into accepting less favorable terms, rather than pursuing truly collaborative relationships [35], [48]. Finally, SMEs often fail to engage in the costly, difficult, long-term planning required to develop and sustain collaborations [35], [49], further undermining their ability to implement effective bridging strategies. Yet, considering that SMEs represent 90% of businesses and more than 50% of employment globally [50], exploring their unique challenges and supply chain risk management approaches is imperative.

C. *A Fit Perspective on Risk Mitigation Strategies*

The concept of fit is well-established in the general management literature. A universal management approach seeks to identify the best practices [51], whereas a fit approach assumes that the best practices depend on the context [7] and that the effectiveness of managerial decision levers is heavily influenced by the context in which they are embedded. This fit approach reflects the philosophy of the contingency theory [7]. Understanding the relationship between contextual factors and managerial decisions in turn can help predict the latter's impact on performance [52].

Operations and supply chain management research has cited the importance of fit [13], [53]–[55]. Since Sousa and Voss's [52] article first appeared, there has been growing interest in understanding fit, including in the SCRM domain. A small but growing stream of research investigates the fit of various contextual factors and different SCRM approaches. Fit analysis can take many forms, including moderation effects, mediation effects, cluster analysis, gestalts or fit to an ideal profile, [8], [56], each providing useful insights. This growing body of literature on SCRM fit presents a variety of contextual factors and relies on different types of fit analysis. For example, focusing on moderation analysis, Manuj and Mentzer [55] describe how organizational traits, such as team composition and inter-organizational learning, influence the effectiveness of different risk mitigation strategies. Similarly, in studying inter-organizational factors, such as trust or supplier dependence, Mishra et al. [54] argue for moderation of relational parameters on the beneficial effects of the mitigation strategies deployed.

Another stream of SCRM work, on the other hand, has adopted a deviation from an ideal profile approach. For example, Srivastava and Rogers [57] propose that there should be significant differences in how organizations manage their supply chain risks in different sectors and show that poor fit with sector-specific traits results in negative performance. Some authors combine several forms of fit analyses. In this sense, González-Zapatero et al. [13], apply an analysis of deviation from an ideal profile to explain how the efficacy of mitigation strategies is contingent upon their perceived utility, and how the presence of a risk manager moderates this dependency. Studies adopting a deviation from an ideal profile approach are relatively scarce. However, this type of analysis allows the inclusion of a large number of variables, making it a useful approach for managers dealing with complex contexts.

Our study builds on this stream by employing a double fit analysis grounded in 'the deviation from an ideal profile approach' discussed earlier. The first dimension of our analysis assesses the extent to which SMEs' mitigation efforts are aligned with the actual profile of external risks they face. The second dimension examines whether this alignment is consistently achieved across different segments of the supply chain (upstream, in-house, and downstream). The importance of striking an appropriate balance between external vulnerabilities and internal mitigation capabilities has been well recognized in the literature [9]–[11]. While underinvesting in risk mitigation may increase a firm's exposure, overinvesting can be unnecessarily costly, potentially outweighing the benefits [19]. Despite this, there is limited analysis of how such fit influences operational risk at different points in the supply chain (e.g. inputs, outputs), which may in turn impact firms' financial results.

However, the impact of this balance or fit on operational performance at different levels of the supply chain (inputs, outputs), and, more importantly, the disaggregated analysis of this fit across each part of the supply chain that could be a useful tool for optimizing SCRM efforts remain unexplored.

To address these gaps, we propose a novel framework consisting of three components. These components are based on the deviation from an ideal profile analysis and reflect the extent to which risk mitigation efforts underestimate the external risk faced by suppliers, in-house by the focal SMEs, and by customers. We label this deviation Upstream RMD, In-house RMD and Downstream RMD.

This approach has important practical applications for SCRM in SMEs. SMEs experience unique challenges to manage supply chain risks [58] due to fundamental differences relative to large companies, with respect to access to financial, technological, and human resources. In general, the "best practice is [typically] identified in resource rich large enterprise contexts" [58, p. 44]. The differences between what is feasible for an SME [59] versus a large company are evident in all the stages of SCRM, particularly when they lack the resources needed to implement a formal SCRM strategy, processes, or systems [60]. For example, SMEs likely are less able to identify or assess the level of mitigation effort they should undertake [61]. In terms of mitigation strategies, they may not have access to a wide range of options, or they may be unable to implement them at the scale a larger company does. As such, effective supply chain mitigation strategies must be tailored to the realities of resource-constrained SMEs, who often face strategic trade-offs. Our novel RMD framework takes this specificity into account by offering a practical tool to help SMEs optimize resource allocation, both in terms of knowledge and financial investment, for SCRM.

III. Conceptual Model and Hypothesis

Expanding on the notion of fit [8], [54], [55] we present our conceptual model in Figure 1, designed to introduce the concept of RMD, which captures the perceived shortfall of SMEs' supply chain mitigation efforts relative to the level of external risks in different areas of their supply chains (upstream, in-house, and downstream). In favor of greater empirical parsimony, and assuming that materials primarily flow downwards in the supply chain, and our model proposes that managing RMD at any of these areas of the supply chain should impact operational risk at the same level of the supply chain, as well as downstream.

Figure 1 about here

As detailed in our literature review (Section II.B), mitigation strategies activate different mechanisms (e.g., risk sharing, redundancy, collaboration) that reduce dependence on supply chain components (upstream, in-house, and downstream). Upstream mitigation efforts reduce supplier dependence, thereby enhancing the buyer's bargaining power to secure targeted operational performance outcomes, such as quality, delivery, and cost [44]. For example, upstream mitigation may involve adopting a comprehensive and formal contract with suppliers that includes provisions and measures to address various contingencies [62], including external risks [30]. However, doing so is often very costly for resource-constrained SMEs, both financially and in terms of knowledge [63]-[64]. SMEs that are able to assess their suppliers' exposure to external risks and, despite these challenges, deploy a comparable level of mitigation effort, are likely to reduce their input OR. Therefore, we hypothesize:

H1: The extent of RMD in an SME's upstream supply chain is positively related to the degree of its input OR.

Moreover, RMD at the upstream level can increase output OR. Returning to our prior example, if SMEs fall short in the use of well-drafted comprehensive formal contracts as an upstream risk mitigation strategy, they might lack effective tools to control suppliers' behavior, including the ability to take legal action against non-compliant suppliers that refuse to provide resources to contribute to a joint disruption response [30]. Such RMD significantly diminishes the SME's capacity to manage its own output OR. For example, its communication with customers, discount offerings, and assortment designs likely to be severely restricted if suppliers fail to meet their commitments on price or delivery, with negative implications for output OR. Therefore, we hypothesize:

H2: The extent of RMD in an SME's upstream supply chain is positively related to the degree of its output OR.

Once SMEs obtain inputs from upstream, they transform them into outputs, in line with market demands. If SME managers perceive that their in-house operations and processes are exposed to external risks, they should apply an appropriate internal risk mitigation strategy, such as a buffering approach in the form of safety stocks and redundant facilities that can absorb the shocks caused by external risks [43]. Such strategies avoid excessive dependence on specific in-house facilities, or teams for instance. Nevertheless, many SMEs are either reluctant or unable to implement such strategies at sufficient levels due to resource constraints, which in turn increases their exposure to downstream OR. This threat became very obvious during COVID-19; the lack of buffers in SMEs' in-house supply chains led to multiple downstream fulfillment failures [2]. Therefore, we hypothesize:

H3: The extent of RMD in an SME's in-house supply chain is positively related to the degree of its output OR.

When SMEs' customers' external risk increases, demand becomes more unpredictable, and SMEs' ability to meet it strongly depends on the extent of RMD in their downstream supply chains. To mitigate the risk, SMEs might build buffers like redundant transport options [4], [43], diversifying the markets and types of clients worked with [29], or engage in bridging, such as through collective sensemaking and resource mobilization [30], [46]. Again though, SMEs' lack of resources and power imbalances with larger partners make these mitigation strategies difficult to implement. However, inadequate downstream mitigation increases SMEs' reliance on their customers. This dependence enhances the customers' bargaining power, thereby making it more difficult for SMEs to fulfill expectations concerning key output attributes, including quality, cost, or sustainability.

H4: The extent of RMD in an SME's downstream supply chain is positively related to the degree of its output OR

Input OR risks also are likely to be closely related to output OR, as SME's ability to meet customer demands and service level expectations can be directly compromised by a disruption in obtaining adequate inputs from suppliers [65]. Consider the Ericsson case as a well-known example: A fire at a Philips semiconductor plant prevented Ericsson from satisfying demand from its customers [29]. Furthermore, if a company does not obtain raw materials and components with the necessary quality, it cannot produce high-quality products [66]. This is also applicable to other operational objectives, such as those pertaining to cost or sustainability. Therefore, the model also includes the following hypothesis:

> *H5: The extent of upstream input OR for an SME is positively related to the degree of its output OR.*

IV. Methodology

A. Sampling and Data Collection

This study focuses on SMEs operating within the Spanish agri-food supply chain, including firms in the food production industry as well as those in the hospitality sector, such as hotels and restaurants. We define SMEs as any firm that employs fewer than 250 persons and has either turnover of less than 50 million euros or a balance sheet total of less than 43 million euros [67]. The European agri-food sector features a high proportion of SMEs [68], and the agri-food supply chain provides a unique opportunity to clarify SMEs' risk mitigation strategies, for several reasons. In particular, it comprises a distinctive mix of characteristics that are common to both manufacturing and service supply chains [69]. The high degree of perishability of its products and materials also creates substantial uncertainties and increases supply chain–related costs [69], [70]. Further complexities arise in upstream supply chains, due to long lead times and a high degree of uncertainty in material supply, such as crop yield volatility caused by weather-related events [70]. Likewise, significant demand uncertainties characterize the downstream stages, because the products and services are subject to demand seasonality [70] and have short product life cycles [71]. To generate the sample pool, we identified 1,422 Spanish agri-food supply chain SMEs from Bureau van Dijk's Sabi (Sistema de Análisis de Balances Ibéricos) database, using the European Commission's SME criteria.

This pool included 530 upstream members (manufacturers) in the Spanish agri-food supply chain and 892 downstream members (hotels and restaurants).

The survey questionnaire (which we detail further in Section IV.B) includes adaptations of items from existing literature. It was evaluated by two academics, two purchasing managers, and two commercial managers to ensure its clarity and readability. The survey was conducted between March and May 2021. To increase response rates, we followed the methods suggested by Dillman [72]. First, all of the 1,422 SMEs identified were contacted by telephone and asked to participate. Second, an email sent to these SMEs provided further information about the study and a link to the online survey. Third, in two further rounds of calls and emails, we reminded and encouraged them to complete the survey. To ensure that the respondents had sufficient knowledge about SCRM, we explained the purpose of the study and informed them that, if possible, the questionnaire should be completed by senior managers involved in procurement or sales. We received a total of 213 responses: 106 from the upstream SMEs and 107 from the downstream SMEs, for an overall response rate of 14.9%. Table I provides detailed information about the companies and respondents.

Table I about here

Similar to Durach et al. [73], to test for non-response bias, we compared key firm attributes (operating income, total assets, number of employees) between the first 50 and the last 50 responses, as well as between the population and the sample [74]. Because we found no significant differences, non-response bias does not appear to be a serious concern (Table II).

Table II about here

To reduce the risk of common method bias, we followed Podsakoff et al.'s [75] recommendations when designing the questionnaire. The questions corresponding to the dependent variables appeared before those corresponding to the independent variables. The sections related to each variable were visually separated. Moreover, Harman's test revealed that the items in our model do not load on a single factor but rather on many different factors, and 19 of them achieve an eigenvalue greater than 1 and account for a small percentage of variance (from 1% to 7.1%). We obtained similar results when we performed the same analysis with a pairwise approach. Finally, we built the constructs in our model as indexes, calculated using the formulas described next. Because indexes corresponding to the independent variables compute differences, this method eliminates the risk of artificial correlations derived from a halo effect, which also avoids potential sources of common method bias [76].

B. Measurement Development

To ensure the quality of the measures for this study, we used existing measures and adapted them as necessary. The scales are in the Appendix. All the variables in this research were measured using 7-point Likert scales, ranging from "very low" to "very high."

1. Risk mitigation deficit

In line with a fit perspective, our RMD measure is based on profile deviation. We constructed three versions of the RMD measure to distinguish deficits that are upstream, in-house, or downstream. In each case, we computed RMD as the positive difference between two range scales (0,1). The first scale measured external risk (ER), and the second measured the risk mitigation effort (RME) that took place upstream, in-house, or downstream, respectively (i.e., RMD = ER − RME if ER > RME and RMD = 0 if ER < RME). To compute the ER scale, we used the surveyed companies' responses to questions about the probability and seriousness of different external risks, as typically appear in SCRM studies, including natural disasters, health crises, political adversities, economic crises, sociologically adverse changes, and technological difficulties [20], [40], [77], [78]. As is also common in prior literature [18], [79], [80], we computed each external risk as the product of probability and severity, then generated the scale with the following formula:

$$\text{ER} = (\textstyle\sum_{i=1}^{6}(\boldsymbol{External\ Risk\ i\ Probability} \times \boldsymbol{External\ Risk\ i\ severity}))/\mathbf{6})/\mathbf{49.}$$

The mean risk thus comprises six different external risks (see the Appendix), divided by the amplitude of the scale, to reduce it to a percentage-type scale with values between 0 and 1.

For the RME scale, we used the surveyed companies' responses to questions about the degree to which they implemented each of the risk mitigation strategies in Table III, which we adapted from previous research [20], [27], [29], [40], [41]. We then created the scale according to the following formula:

$$\text{RME} = [\textstyle\sum_{i=1}^{n}(\boldsymbol{Risk\ Mitigation\ Strategy\ i})/\boldsymbol{n}]/\mathbf{7.}$$

In this case, we computed the average implementation of the group of strategies (see the Appendix) for each area of the supply chain (upstream, in-house, and downstream). We then divided each mean by the amplitude of the scale to reduce it to a percentage-type scale with values between 0 and 1. Therefore, RMD reflects the extent to which implemented mitigation strategies fail to reach a level that is considered necessary to match the level of external risk.

Table III about here
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2. Operational Risk

To compute OR, we used each company's responses to questions about the probability and severity of failing to meet key operational objectives (e.g., price, quality, delivery, sustainability aspects) (see the Appendix), upstream (for input OR) and downstream (for output OR) in the supply chain [20], [27], [28], [54], [79], [81]. We computed the risk in each area using the mean, for all items, of the product of probability and severity, according to the following formula:

$$\text{OR} = [\textstyle\sum_{i=1}^{6}(\boldsymbol{Failure\ i\ Probability\ \times\ Failure\ i\ Severity})/\mathbf{6}]/\mathbf{49}$$

Then we divided the mean by the amplitude of the scale to establish a range (0,1).

These measures are formative scales [82] [83] and meet the pertinent conditions: (1) each item measures a conceptually different aspect, (2) a change in any item would lead to a change in the variable and not the other way around, and (3) a complete view of the variable requires accounting for all of the items included. As detailed in the formulas the mean was used to compute ER, RMD and OR, which ensures the replicability of the study. Having calculated the means, they were divided by the scale amplitude to enable the positive difference between ER and RME to be calculated. The use of similar scales in previous works [9] [24], which were shown to have an impact on variables such as profitability in other samples, acts as an external validation for our scales.

3. Control Variables

To control for the effects that different contextual variables may have on risk, upstream or downstream, we accounted for three control variables: industry sector, number of employees, and operating income. Because SCRM can be strongly influenced by sector [57], we used the sector control variable to reflect that the sample represents two groups within the agri-food sector, namely, upstream manufacturers and downstream restaurants and hotels. The number of employees and operating income provide indicators of size. Because SCRM processes and systems are resource intensive, firms likely have significantly different capabilities to invest, even within the SME segment [58]. We extracted all of these measures from the Sabi database.

C. Analysis

To test the proposed hypotheses, we first conducted multiple regression analyses. Although the independent variables were significantly correlated, they were not exceedingly high. To mitigate potential issues of interpretation, we first ran regressions with only control variables. Next, we introduced each independent variable in separate regression models to assess their individual effects. In instances where multiple independent variables exhibited significance, we employed stepwise regression to identify those with the strongest explanatory power. Then, to assess the robustness of the model, we conducted an additional set of regressions in which we substituted the model's independent variables, upstream RMD, in-house RMD, and downstream RMD, with corresponding RMEs. We then tested the effect of RMEs on input OR and on output OR. According to the logic of our model, these verification regressions were not expected to yield significant results.

V. Results

Table IV presents the correlations among the model variables, while Table V provides the regression results used to assess the impact of RMD on input OR. As the first model (Mod1) shows, the effect of the control variables on input OR is not significant. The second model (Mod2) adds the effect of upstream RMD on input OR, and these results lead us to reject H1. Although they are not included in our hypotheses, as a robustness test, we performed regressions of in-house RMD (Mod3) and downstream RMD (Mod4) on input OR. According to our model logic, these effects should not be significant, and the results are consistent with this expectation. The effect of internal RMD on input OR is not significant, whereas the downstream RMD effect is significant but negative.

Tables IV and V about here

Table VI presents the results of the regression models used to test the effect of the RMD on output OR. As before, Mod1 includes only the control variables. The results of Mod2 provide support for H2, indicating that higher upstream RMD is associated with increased output OR. Similarly, the results of Mod3 also support H3, showing that higher in-house RMD leads to higher output OR. However, the Mod4 results do not support H4, and we found no evidence that reducing downstream RMD reduces output OR. Finally, the results of Mod5 provide support for H5, that is, an increase in input OR increases leads to increase in output OR. When we introduced all the independent variables simultaneously in a stepwise regression, the variable with the greatest explanatory power, in terms of the variance, was input OR, followed by upstream RMD.

Table VI about here

In Tables VII and VIII, we also report the effects of increasing the implementation of risk mitigation strategies, without controlling for whether a deficit exists in relation to the level of perceived external risk upstream, in-house or downstream. As expected, these effects are not significant (Table VII, Mod3) or are significant but produce a counterproductive effect (Table VII, Mod2 and Mod4). Both results support the logic of our model.

Tables VII and VIII about here

VI. Discussion

Overall, the results provide strong support for our proposed model. Reducing RMD at different stages of the supply chain is positively associated with lower OR, especially when addressed in the upstream and in-house stages (H2 and H3). This highlights the importance of early-stage mitigation to manage OR further downstream. Our robustness checks (Tables VII and VIII) further provide support for this. Interestingly, the expected positive effects of RME on OR were not observed, but in some cases, some coefficients were statistically significant with contrasting signs. This may likely reflect reverse causality, that is firms experiencing higher OR may increase their mitigation efforts in response, but such efforts may not reduce OR unless they effectively address existing RMD. These findings underscore the importance of our targeted approach to risk mitigation. Rather than spreading mitigation efforts thinly across the supply chain, SMEs should focus on identifying specific areas of their supply chains where mitigation deficits exist. Such approaches would enable more effective use of limited resources and greater impact on risk mitigation.

However, H1 and H4 were not supported by the results. A plausible explanation may lie in the imbalance of dependence between suppliers and customers of Spanish agri-food and hospitality SMEs. In such contexts, attempts to reduce RMD by aligning mitigation efforts with upstream or downstream ER levels may be neither efficient nor necessary for reducing operational risk [84]. For example, bridging strategies such as collaboration with a dominant partner can become symbolic or superficial if that partner is not genuinely interested in collaboration. On the other hand, engaging with a less powerful partner may not be sought after unless it is absolutely necessary. Likewise, buffering strategies such as multiple suppliers or distribution channels may be unworkable when the market is highly concentrated [84].

There are reasons to expect this dependence imbalance may be occurring both upstream and downstream. In the agri-food sector, SMEs typically operate within highly fragmented supplier markets where vendors have limited bargaining power [84]. In the hospitality sector, suppliers may be somewhat larger than SMEs, but their high number similarly reduces the SMEs' dependence on suppliers. However, SMEs in both sectors were significantly affected by unusually high inflation in 2021 [85]-[86], which, conversely, may have increased their operational risk due to greater dependence on suppliers.

Regarding their dependence on customers, especially in the agri-food sector, SMEs tend to have limited power relative to large retail customers, making downstream mitigation strategies (e.g., promotions, discounts, communication, or credit insurance) less effective. Furthermore, in the Spanish hospitality industry, which is highly dependent on overseas customers, mitigation strategies such as promotions may have been ineffective due to international travel restrictions in place at the time. Another possible explanation is that downstream mitigation strategies such as pricing to influence demand or using alternative customer channels often require fewer resources than upstream strategies. As a result, downstream strategies can be devised or deployed at the last minute, whereas upstream mitigation tends to be more complex and time consuming [69]. If downstream RMD is implemented continuously or reactively, it may not lead to substantial changes in output OR.

Finally, we identified one unexpected and significant effect which is not linked to any of our hypotheses but was included in the regressions as further robustness test. Downstream RMD shows a significant but negative effect on input OR. An explanation for finding could be reverse causality. If input OR increases—indicating that inputs are failing to meet operational expectations (e.g., in terms of quality, timeliness, or sustainability)—firms may respond by intensifying downstream mitigation efforts (e.g., offering discounts or running promotions), thereby reducing downstream RMD.

A. Theoretical Contributions

This study offers several theoretical contributions. First, our findings contribute to the development of a niche in the literature that deserves specific attention, namely SCRM in SMEs, due both to their significance in business and to the particular challenges they face. Due to their limited resources and difficulty in implementing broad, comprehensive risk mitigation strategies for many different eventualities, SMEs are likely to need to focus their limited resources on a few best-fit mitigation strategies to address high-priority external supply chain risks. Our fit approach to external risk mitigation is well-suited to SMEs, because their nimble nature, due to structural simplicity [87], enables them to adapt better to ever-changing external environments, including rapid deployment of best-fit supply chain risk mitigation strategies.

Second, we contribute to the emerging SCRM literature that adopts a contingent or fit perspective (e.g., [55], [54], [9], [88], [89]). Using a deviation-from-ideal profile analysis—still rare in this field [9], [13]—we propose an RMD framework that builds on the notion of fit and aligns with prior work (e.g., [9]–[11], [42]), which emphasizes that effective risk mitigation is not about increasing efforts per se but about ensuring that mitigation efforts are commensurate with the level of risk. This type of fit analysis allows for the inclusion of a wider range of variables than alternative approaches (i.e., moderation, mediation), thereby providing useful complementary insights [8]. Moreover, our disaggregated framework and findings demonstrate that RMD must be contextualized across different parts of the supply chain: upstream, in-house, and downstream

B. Managerial Contributions

This study offers several practical implications for SME managers. It introduces the RMD measure, a simple and systematic tool designed to help resource-constrained SMEs identify gaps in mitigation across the supply chain and reduce OR exposure. Since SMEs often lack the capacity to implement complex risk management systems, the RMD is particularly valuable. It can be easily integrated into existing expert judgment or survey-based systems without requiring major investments. The RMD helps SMEs establish clear risk indicators and focus their mitigation efforts where vulnerabilities are most critical, whether upstream, internal, or downstream.

Rather than replicating industry-wide methods typically designed for larger firms, SMEs should adopt a contingency-based approach that fits their specific operational contexts and constraints. The COVID-19 pandemic showed how severely firms can be affected by unexpected disruptions, especially through their supply chain partners [90]. This highlights the need for practical tools like the RMD. By applying this approach, SMEs can proactively anticipate external threats, close mitigation gaps, and strengthen their overall resilience.

VII. Conclusion

With this study, we have sought to establish the implications of efforts to mitigate external risks by SMEs. Building on a fit perspective rooted in the contingency theory, we propose a novel RMD measure, which can apply to upstream, in-house, and downstream risks. In assessing the relationship between RMD and OR effects, both upstream and downstream, using a unique sample of 213 Spanish SMEs from the agri-food supply chain, we offer notable support for the fit perspective. We also offer interesting insights regarding the relationship between RMD and operational risk effects.

Some limitations of our study represent opportunities for further research. First, we measured the independent variables using indexes, which helped reduce the risk of artificial correlations with other elements of the analysis due to halo effects and common method bias. However, more objective measures would be a valuable extension—for example, using data on the evolution of pandemics (e.g., number of infections), natural disasters, or other crises (e.g., economic or social). Developing a hybrid RMD measure that incorporates such objective data and extends beyond the SME context would be a natural progression of this research. Second, since the data were collected between March and May 2021, the cross-sectional design limits our ability to understand how the relationship between RMD and operational risk (OR) evolves across different stages of the pandemic. Incorporating a temporal dimension, such as longitudinal data, would offer deeper insights for both theory and practice. Third, it may also be worthwhile to explore whether operational risk increases more sharply after RMD crosses a certain threshold, rather than assuming a linear relationship. Fourth, our model was tested with SMEs in the agri-food supply chain; however, specific contextual factors may influence the results. Therefore, further research in other sectors would be a valuable extension. Lastly, future studies could examine relevant boundary conditions—such as supply chain complexity or organizational slack—to better understand when and for whom the effects of RMD are more pronounced.

Disclosure statement

The authors report no potential conflicts of interest.

Ethics Approval

This work does not cover any ethically sensitive topics. As per the authors' institutional ethical regulations, this research is exempt from ethics approvals.

Data Availability Statement

The data that supports the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available, due to the commitment established to the research participants.

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Table I. Sample Distribution

	Frequency	Percentage
Number of employees		
50–100	137	64%
101–150	43	20%
151-200	22	10%
200-250	11	6%
Total	213	100%
Firm sales (millions of Euros)		
≤5000	22	10%
5000-10000	76	36%
10001-20000	58	27%
20000-30000	23	11%
Over 300001	34	16%
Total	213	100%
Supplier dependence (value of supplies/value of final product)		
≤25%	46	22%
26-50%	85	40%
51-75%	67	31%
76-100%	15	7%
Total	213	
Respondent profile		
CEO/general director /Senior Vice President	213	100%
Age		
25-34	22	10%
35-44	62	29%
45-54	82	38%
>54	47	22%
Time in this position		
<2 years	21	10%
2-5 years	25	12%
6-10 years	50	23%
11-20 years	64	30%
>20 years	53	25%
	213	

Table II. Test for Non-Response Bias

	Population vs. Sample **F**	50 first vs. 50 last **F**
Operating Income	.636 (p = .942)	1.744 (p = .187)
Total Assents	.547 (p = .982)	.202 (p = .653)
Number of Employees	1.292 (p = .185)	.046 (p = .830)

Table III. Upstream Risk Mitigation Deficit Calculation Illustration

Upstream External Risk				Upstream Risk Mitigation		Upstream Risk Mitigation Deficit	
	P	S	PxS		L		
ER1	7	7	49	RME1	7		
ER2	6	2	12	RME2	2		
ER3	5	6	30	RME3	1		
ER4	7	5	35	RME4	3		
ER5	6	6	36	RME5	3		
ER6	1	1	1	RME6	3		
Σ / n			27	Σ / n	3		
SA			49	SA	7		
(a) Σ / SA			0,6	(b) Σ / SA	0,5	(a)-(b)	0,1

Er(i)= External Risk(i); P=Probability; S=Severity; PxS= Probability x Severity; SA= Scale Amplitude; RME (i)= Risk Mitigation Effort(i). L= Level

Table IV. Correlations

	1	2	3	4	5	6	7
1. Upstream Risk Mitigation Deficit	1						
2. In-housel Risk Mitigation Deficit	.472***	1					
3. Downstream Risk Mitigation Deficit	.232**	.355***	1				
4. Input Operational Risk	.051	.074	−.124†	1			
5. Output Operational Risk	.272***	.177**	-.086	.376***	1		
6. Operating Income	−.136*	−.125†	.086	−.001	−.015	1	
7. Number of Employees	−.017	−.039	.025	.057	−.030	.292**	1
8. Sector	−.251***	−.212**	−.006	−.107	−.016	.429***	0.85

†$p < .1$, *$p < .05$, **$p < .01$, and ***$p < .001$; two-tailed Pearson correlation coefficients.

Table V. Impact of Risk Mitigation Deficit (RMD) on Input Operational Risk (IOR)

		Dependent Variable: Input Operational Risk			
Independent Variable		Mod1	Mod2	Mod3	Mod4
Upstream RMD	(H1)		.027		
In-house RMD	(Robustness Test)			0.57	
Downstream RMD	(Robustness Test)				−.131†
Control Variables					
Number of Employees		.057	.057	.058	.057
Operating Income		.038	.039	.040	.052
Industry Sector		−.128†	−.122	−.118	−.145†
R^2		0.17	.018	.020	.034
$\Delta\Delta R^2$		.17	.001	.003	.017†
F		1.208	.938	1.067	1.826

†$p < .1$, *$p < .05$, **$p < .01$, ***$p < .001$.

Table VI. Impact of Risk Mitigation Deficit (RMD) on Output Operational Risk (OOR)

		Dependent Variable: Output Operational Risk					
Independent Variable		Mod1	Mod2	Mod3	Mod4	Mod5	Mod6
Upstream RMD	(H2)		**.286*****				.276***
In-house RMD	(H3)			**.182***			
Downstream RMD	(H4)				−.087		
Input Operational Risk	(H5)					**.383*****	**.376*****
Control Variables							
Number of Employees		−.028	−.032	−.026	-.028	−.050	−.054
Operating Income		−.001	.010	.006	.009	.015	−.004
Industry Sector		−.013	.054	.022	-.018	.036	.100
R^2		.001	.078	.033	.008	.145	.216
$\Delta\Delta R^2$			.077***	.031*	.007	.144***	.071***
F		.074	4.379**	1.748	.445	8.828***	11.430***

†$p < .1$, *$p < .05$, **$p < .01$, ***$p < .001$.

Table VII. Impact of Risk Mitigation Effort (RME) on Input Operational Risk (IOR)

	Dependent Variable: Input Operational Risk			
Independent Variable:	Mod1	Mod2	Mod3	Mod4
Upstream RME		**.147***		
In-house RME			.085	
Downstream RME				**.117+**
Control Variables				
Number of Employees	.057	.049	.056	.061
Operating Income	.038	.047	.042	.047
Industry Sector	−.128+	−.166†	−.149†	−.131†
R^2	.17	.37	.24	.30
ΔΔR^2	.17	.020*	.007	.013
F	1.208	2.011†	1.269	1.636

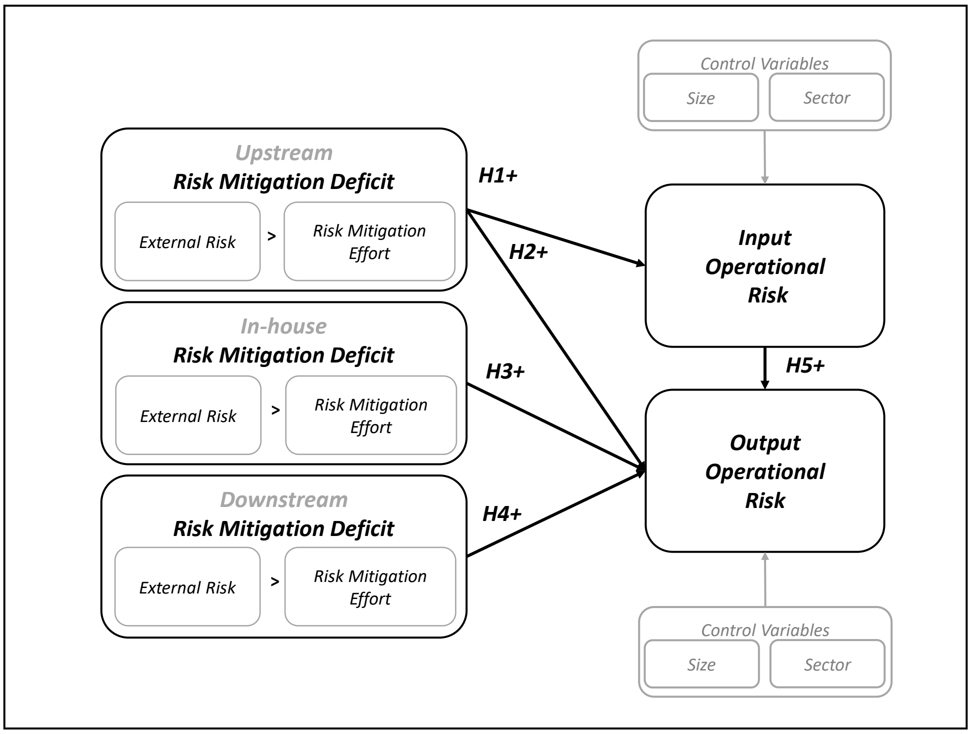
†$p < .1$, *$p < .05$, **$p < .01$, ***$p < .001$.

Table VIII. Impact of Risk Mitigation Effort (RME) on Output Operational Risk (OOR)

	Dependent Variable: Output Operational Risk			
Independent Variable	Mod1	Mod2	Mod3	Mod4
Upstream RME		.042		
In-house RME			.040	
Downstream RME				−.035
Control Variables				
Number of Employees	.057	−.031	−.029	−.030
Operating Income	.038	.002	.001	−.004
Sector	−.128†	−.024	−.023	−.013
R^2	.17	.003	.007	.002
ΔΔR^2	.17	.002	.001	.001
F	1.208	.142	.314	.118

†$p < .1$, *$p < .05$, **$p < .01$, ***$p < .001$.

Figure 1: Conceptual Model



Appendix: Scale Development

	Scale	Sources
	Upstream External Risk Please rate from (1 = "very low" to 7 = "very high") P1: Probability of **my suppliers** suffering disruptions resulting from the following situations: S1: Severity of the negative impact on my company if my suppliers were to experience disruptions from the following situations: **Company External Risk** Please rate from (1 = "very low" to 7 = "very high") P2: Probability of **my company** being disrupted by the following situations: S2: Severity of the negative impact that disruptions from the following situations would have on my company: **Downstream External Risk** Please rate from (1 = "very low" to 7 = "very high") P3: Probability of **my clients** suffering disruptions resulting from the following situations: S3: Severity of the negative impact on my company if my clients were to experience disruptions from the following situations:	
ER1	Natural disasters (e.g., floods, earthquakes, fires)	Tang, 2006; Ho et al., 2015
ER2	Health crises (e.g., diseases, pandemics)	Stecke and Kumar, 2009
ER3	Political adversities (e.g., political instability, armed conflicts, terrorism, strikes, adverse laws and regulations, tariffs)	Stecke and Kumar, 2009; Ho et al., 2015
ER4	Economic adversities (e.g., crisis, inflation, adverse exchange rates, adverse interest rates)	Stecke and Kumar, 2009
ER5	Sociological adversities (e.g., adverse changes in society's behavior, lifestyles, preferences)	Tang, 2006
ER6	Technological adversities (e.g., changes in technologies that negatively affect suppliers)	Rangel, Oliveira y Leite, 2014; Creazza et al., 2022
	Input Operational Risk Please rate from (1 = “very low” to 7 = “very high”) the: 1. Probability of my firm having disruptions from: 2. Severity for my firm of having disruptions from:	
IOR1	Suppliers significantly increasing their prices	Zsidisin and Ellram, 2003; Lavastre et al., 2014; Hallikas and Lituangas, 2016; Wiengarten et al., 2016
IOR2	Suppliers not meeting quality requirements	Zsidisin and Ellram, 2003; Stecke and Kumar, 2009; Hallikas and Lintukangas, 2016
IOR3	Suppliers not meeting delivery dates	Zsidisin and Ellram, 2003; Stecke and Kumar, 2009; Lavastre et al., 2014; Mishra et al., 2016; Hallikas and Lintukangas, 2016; Wiengarten et al., 2016
IOR4	Suppliers not being able to adapt their product/service design to requirements	Stecke and Kumar, 2009; Wiergarten et al., 2016
IOR5	Suppliers not meeting international sustainable standard on social issues (e.g., excessive working hours, unfair wages, discrimination in terms of age, politics, religion, sex, race, or something else)	Giannakis and Papadopoulos, 2016
IOR6	Suppliers not meeting international sustainable standards on environmental issues (e.g., emissions, resources waste, packaging)	Giannakis and Papadopoulos, 2016

	Output Operational Risk Please rate from (1 = "very low" to 7 = "very high") the: 1. Probability of my firm having disruptions from: 2. Severity for my firm of having disruptions from:	
OOR1	Firm not meeting customers' price preferences	Zsidisin and Ellram, 2003; Lavastre, et al., 2014; Wiengarten et al., 2016
OOR2	Firm not meeting customers' quality preferences	Zsidisin and Ellram, 2003; Stecke and Kumar, 2009; Hallikas and Lintukangas, 2016
OOR3	Firm not meeting customers' delivery dates requirements	Zsidisin and Ellram, 2003; Stecke and Kumar, 2009; Lavastre et al., 2014; Mishra et al., 2016; Hallikas and Lintukangas, 2016; Wiengarten et al., 2016
OOR4	Firm not meeting customers' flexibility requirements (product adaptation)	Stecke and Kumar, 2009
OOR5	Firm involuntarily damaging customers (e.g., injuries, intoxication, stress)	Hofmann et al., 2014; Giannakis and Papadopoulos, 2016
OOR6	Firm involuntarily damaging the natural environment (e.g., emissions to the atmosphere, waste)	Hofmann et al., 2014; Giannakis and Papadopoulos, 2016
	Upstream Risk Mitigation Effort Assess the extent of risk mitigation strategy deployed in your supply chain (1 = "very low" to 7 = "very high"):	
RME1	Penalizing suppliers for non-compliance with the agreed conditions (e.g., delivery time, quality)	Tang, 2006; Lavastre et al., 2014
RME2	Hiring insurance to mitigate the effect of non-compliance in the deliveries of suppliers	Stecke an Kumar, 2009
RME3	Using various modes of transportation to get supplies to business	Tang, 2006; Stecke and Kumar, 2009
RME4	Maintaining multiple suppliers in terms of, for example, components, type of raw material, services and supply	Chopra and Shodi; 2004; Stecke and Kumar, 2009; Thun and Hoening, 2011; Kiluby, 2016
RME5	Requiring key suppliers to maintain an extra level of stock (e.g., raw materials, intermediate or finished products) and/or a certain capacity slack to ensure supply	Chopra and Shodi, 2004; Tang; 2006; Stecke and Kumar, 2009; Lavastre et al., 2014
RME6	Share information (e.g., on demand, inventories, organizational aspects) and collaborate (e.g., staff training, quality management, common software development) with key suppliers.	Chopra and Shodi, 2004; Thung and Hoening, 2011; Stecke and Kumar, 2011; Lavastre et al., 2014; Kilubi, 2016
	In-house Risk Mitigation Effort Assess the extent of risk mitigation strategy deployed in your supply chain (1 = "very low" to 7 = "very high"):	
RME7	Geographically dispersing operations by increasing the number of offices/plants/facilities	Stecke and Kumar, 2009
RME8	Increasing the multifunctionality/versatility of human resources to facilitate mobility between, for example, jobs, headquarters and facilities	Stecke and Kumar, 2009
RME9	Maintaining an extra level of stock in facilities (e.g., raw materials, intermediate or finished products) and/or a certain amount of capacity to ensure service to customers	Chopra and Shodi, 2004; Tang; 2006; Stecke and Kumar, 2009; Lavastre et al., 2014
	Downstream Risk Mitigation Effort Assess the extent of risk mitigation strategy deployed in your supply chain (1 = "very low" to 7 = "very high"):	
RME10	Using various methods (e.g., letters of credit, advance deposit, cancellation policies) to ensure the payment of clients' reservations/purchases	Stecke and Kumar, 2009
RME11	Diversifying the markets and types of clients worked with	Chopra and Shodi, 2004
RME12	Expanding the sales channels used (e.g., physical store, online, representatives)	Chopra and Shodi, 2004

RME13	Sharing information (e.g., on demand, inventories, organizational aspects) and collaborating (e.g., staff training, quality management, common software development) with main clients	Chopra and Shodi, 2004; Thung and Hoening, 2011; Stecke and Kumar, 2011; Lavastre et al., 2014; Kilubi, 2016
RME14	Boosting demand through discounts/prices	Tang, 2006
RME15	Promoting demand through the management of assortment or range of products and services (e.g., offer complementary products and services, substitute novel or scarce products or services)	Chopra and Shodi, 2004; Tang, 2006; Stecke and Kumar, 2009
RME16	Boosting demand through the management/rotation of the position of the firm's products/services at the point of sale (physical or online)	Chopra and Shodi, 2004; Tang, 2006; Stecke and Kumar, 2009
RME17	Promoting demand through communication tools (e.g., social networks)	Tang, 2006; Stecke and Kumar, 2009