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UNCERTAINTY AS AN ANTECEDENT OF THE SUPPLY CHAIN RISK: DOES SUPPLY CHAIN FLEXIBILITY MATTER IN RISK MITIGATION?

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Abstract

Purpose: This study aims to address the existing research gap, as well as to explore the various types of flexibility which could contribute in mitigating supply chain risks.

Methodology: In this regard, we consider three aspects under SCR namely; manufacturing process risk, delivery risk, and supply risk. The study explores the relationships among supply chain risk and environmental uncertainty, and the moderating role of supply chain flexibility by employing data of 91 manufacturing companies and develop a structural equation modelling.

Results: Developing economies are contributing well in the global trade and are responsible for 50% of the generated global output. They present future prospects for economic growth and pose challenges mainly because of immature supply chain operations. Considering the critical role of emerging economies in global supply chain, such as India and China, it is also important to observe the moderating and driving supply chain risk factors in these regions. It is assumed that this study will not only fill the existing gap in the literature of SCRM but will assist researchers and practicing managers, by enabling them to fully understand certain types of supply chain flexibility, thus reducing the SCR under business environments.

Keywords: *flexibility, uncertainty, supply Chain risk, SCRM*

INTRODUCTION

Tim Crook, the CEO of Apple Inc. on the supply shortfall for the iMac 2012, commented that now timers would not have to wait longer than what they had done before. The new iMac has suffered with production issues during sale in December. The company announced that this issue has emerged due to Apples' unique screen lamination system, which was used for developing its new design, changing the desktop into thinner profile display as compared to its previous design. Whether it is mobile phone, automobiles, high-end technological products or computers, in order to survive in industry, shorter life cycles need persistent offerings of new products. Consequently, firms function under highly uncertain industrial environment (Ciccullo *et al.*, 2018; Dierker *et al.*, 2018; Dincer and Kilinç, 2018). Such as, persistent product offerings trigger demand uncertainty (Fayezi, Zutshi& O'Loughlin, 2017). Whereas, higher customization level and wider product range coexisting with advanced technological needs causes considerable uncertainties in production and supply processes. Therefore, these organizations are faced with substantial risks in the form of delivery and production delays, and supply interruptions, resulting in lost sales, decline in financial performance, and loss of reputation. A survey was conducted on risk management and global supply chain, in an attempt to indicate that frequent variations in manufacturing demands and product supply, due to less standardization of services and goods and persistent offerings of new products are the major drivers behind supply chain complexity (Strom, 2013; Dincer and Kilinç, 2018). These drivers cause supply chain complexity resulting in higher supply chain risk. However, according to (Wieland and Marcus Wallenburg, 2012), these risks are associated and occur frequently in complex supply chains and are commonly referred as operational risks. This study discuss the driving factors of SCOR and measures to mitigate these risks.

The rapidly increasing aftermaths of supply chain risks directly on the firms' performance has gained considerable attention by industry practitioners and academic researchers, particularly in the area of SCM (Dogan and Dogan, 2018; Kumar *et al.*, 2018). The literature of supply chain is rich with studies regarding how the design of SC can be helpful in reducing or rolling supply chain risk vulnerability. For example, researchers have declared that the responsiveness of supply chain towards risk can be increased through supplier dependence (Blackhurst *et al.*, 2018) global sourcing and supplier concentration lack of coordination between the partners of SC (Fan & Stevenson, 2018) and focusing towards cost efficient SC (Wong et al., 2006). Although, a limited number of studies were found which have explored the various mechanisms for mitigating SCR and dealing with such vulnerabilities (Wiengarten *et al.*, 2015).

In most cases, supply chain flexibility is taken as a key to resolve increasing competitiveness and uncertainty in the market. A number of empirical studies (Scholten *et al.*, 2018) have identified the role of supply chain flexibility under uncertain environments, which has well contributed in the performance of a business. However, only limited studies are available in the literature which have empirically analyzed the contribution of supply chain flexibility to mitigate supply chain risks. For instance, (Gligor, 2018) have observed the importance of SC flexibility to alleviate SC risks through analytical modeling. Since several industry-based researches and practitioners' surveys have mentioned SC flexibility as a key factor

to manage risks under supply chain, therefore, it is still unclear that what kind of and how much flexibility is needed for mitigating such risks. Firms need to be wiser to assess what amount of flexibility is required for the system, as high flexibility is somehow expensive to achieve (Sodhi *et al.*, 2012). Such as, a survey about supply chain innovation exhibited that just 27% responses have shown that SC flexibility is among the two top drivers of SC value. Thus, identification and understanding the contexts is crucial, in which several flexibility types can prove to be helpful in testing the assumptions and minimizing SC risk, using empirical modelling.

During the past decade, the frequent need for empirical research has appeared in SC management and operations management (Roehrich *et al.*, 2017). since it provides help in verification and theory building, as well as in strengthening the nature of association between practitioners and academics under operations management. However, several conceptual studies (Kamalahmadi and Parast, 2016) and case studies have been conducted on the identification and mitigation of supply chain risk, although survey based empirical research is still at an early stage of development (Colicchia and Strozzi, 2012). The scarceness of empirical studies in the area of supply chain risk management (SCRM) has also been highlighted by (Sodhi *et al.*, 2012; Lavastre *et al.*, 2014). It clearly explains the dire need to empirically develop a linkage among various discussed elements, for instance, environmental uncertainty, supply chain risk, and SC flexibility for abridging the available empirical research gap in the literature of SCM and operations management.

THEORETICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

The literature of supply chain management presents a number of sources of uncertainty, which creates uncertain environment for the business firms For instance, three key dimensions of SC uncertainty have been proposed by (Venkatesh *et al.*, 2015; Zhou *et al.*, 2018) these are: technology, supply, and demand. This study will observe the fourth dimension of supply chain uncertainty i.e. manufacturing uncertainty, in order to operationalize the variable of environmental uncertainty. In this regard, various theoretical viewpoints have played their role in explaining the supply chain risk phenomenon. According to (Wu *et al.*, 2017), supply chain risk is the potential divergence from the overall goal or objective, which triggers the reduction of certain value-added activities that are taking place at different levels. SCR can be further classified into operational risk and disruption risk (Wiengarten *et al.*, 2016) where operational risk arises due to lack of coordination among demand and supply and due to high uncertainty, on the other hand, disruption risk is associated with situations for instance, terrorist attack, labor strikes, and natural calamities (Ghadge *et al.*, 2012). In addition, operational risk also refers as internal SCR (Zeng *et al.*, 2012). The supply chain risks associated with diversified manufacturing industries and high tech industrial products were became expensive due to the rapidly changing needs and complex nature of supply chains, thus resulting in sudden variations in demand (Deloitte). Around 46% of the respondents consider risk arising from the company-owned SC operations risks as the main concern of supply chain (Kwak *et al.*, 2018). Therefore, operational risk is the main concern of the present study. The figure 1 shows a conceptual framework indicating that how different aspects of SCF, supply chain risk and environmental uncertainty are somehow linked. However, the relationship among these constructs and corresponding hypotheses have been discussed in more detail in the following subsections.

Supply chain risk and Environmental uncertainty

Companies that possess a product line are commonly attributed with wider variety, higher customization level, and frequent new offerings, may find difficulty in predicting and analysing demand patterns of their goods (Lo and Power, 2010). Whereas, demand uncertainty is considered as the main source of supply chain uncertainty, which accounts for the unknowns that are related with the characteristics of the product. However, other sources of uncertainty are supply uncertainty and manufacturing uncertainty (Huang *et al.*, 2014). The highly customized and innovative product offerings enable companies to achieve a sustainable competitive advantage, which consequently results in increased complexity of upstream suppliers in procurement and manufacturing processes, leading to inflated uncertainty across the supply chain (Wu *et al.*, 2014). Frequent technological changes in production increases manufacturing complexity and drive technical alterations on the suppliers' side. Furthermore, substantial variations in order size can result in frequent changes in the production as well as in the production mix and volume of suppliers' production. Therefore, according to supply uncertainty is referred as the unmanageable and unforeseeable factors in the material flow that are predominantly characterized as the manufacturing variability in volume, product mix, and technological complexity.

On the other hand, (Mangla *et al.*, 2015) defined supply risk as the expected failure in supplying goods with respect to product quantity and quality, which consequently turns into incomplete order. However, (Wu *et al.*, 2014) mentioned that the uncertain market response against innovations aggravates the risk of excessive supplies or shortage in supplies. Meanwhile, due to rapid fluctuations in the characteristics of supply and demand, the probability of losses due to delivering right product late or delivering the wrong product is quite high. Additionally, an increase in the uncertainty of product mix or volume of certain order reduces the ability of a supplier to deliver the right quality at the right time (Thun *et al.*, 2011). The following hypothesis is proposed on the basis of the above discussion:

H1: Firms with greater environmental uncertainty face greater supply risk

According to (Wiengarten *et al.*, 2016), manufacturing process risks are the expected divergences from developing a desirable quantity and quality of products at the right time. Uncertainty because of frequent offerings of new products and

shorter product cycles results in considerable changes in the production sector (Yi *et al.*, 2011). Order fluctuations that arise from customer or unexpected changes in the supply cause changes in the manufacturing operations (Hofmann, 2017). However, organizations find it hard to support stable manufacturing environment at the shop level, if there are greater expectations from the firm to show more flexibility in delivering at a faster pace, flexibility in degree of customization and order size. For instance, significant order size variations requires order expedition, insertion, or variations in product mix and volume, leading to unpredictability of product quality, process yield, and turnout time. Such variations thus result in unreliable and unstable production performance and increases the level of risk in the manufacturing process (Hofmann, 2017). Thus, the proposed hypothesis is:

H2. Firms with greater environmental uncertainty face greater manufacturing process risk.

(Epstein, 2018) stated that maintaining inventory at warehouses and customers' sites are the main strategies that are used by companies for satisfying the requirements of delivery reliability norms. However, the introduction of new products and frequent changes in product together with customization and greater variety will create difficulty in managing inventories of finished goods. Furthermore, market demand uncertainty that are related with innovative and new products having shorter life cycle has the ability to influence the accuracy level of inventory and forecasted demand. The uncertainty in supply, demand, and manufacturing can influence the reliability and delivery quality in terms of providing the right quality and quantity of product at the specified time. Therefore, it is assumed that those organizations that perform under uncertain environments are more susceptible to delivery failures. Thus, we hypothesize that:

H3. Firms with greater environmental uncertainty face greater delivery risk.

Supply chain flexibility as a moderator for supply chain risk

How firms that are exposed to uncertain environment could be able to deal with the challenges arising from supply chain risk? In this regard, review of the studies depicts that timely minimization of adverse effects of uncertainty is very important for the smooth supply chain operations (Lo and Power, 2010). A few researchers (Ho *et al.*, 2015) argued that organizations must invest more on SC responsiveness and SC agility for dealing with disruption risk and for rapidly reacting against market fluctuations. A selection of organizations' SC strategy must depend upon the demand characteristics and genre of products i.e. innovative or functional that is offered (Colicchia and Strozzi, 2012). Several number of researchers have studied the Fisher's model (1997) and confirmed that the alignment among supply chain design and product characteristics is needed for better performance of the firm. A study pointed out the significance of complementing an organizations' operating environment with supply capabilities for staying in line with the ever-changing business requirements (Fan & Stevenson, 2018).

It has been already discussed that supply chain flexibility is considered to be an important lever for minimizing supply chain risk in several industry-based and conceptual studies. Therefore, flexibility is referred to be a firms' ability to react or change with little efforts, performance, cost, or time penalty (Lavastre *et al.*, 2014). According to the literature, the concept of supply chain flexibility revolves around three key dimensions namely; manufacturing flexibility, logistics or distribution flexibility, and supply flexibility. Where manufacturing flexibility is the essential supply chain flexibility component, having the ability to manage uncertainty in meeting customers' requirements and controlling manufacturing processes (Colicchia and Strozzi, 2012). On the basis of definitions presented by (Fan & Stevenson, 2018), manufacturing flexibility is operationalized based on product modification flexibility, volume flexibility, and mix flexibility. The logistics or distribution flexibility is referred to the availability of various options or as the ability for effectively using these options, thus enabling to transform the process of managing storage as well as flow of finished goods, materials, related information, and services from the place of origin to the final end point, within changing conditions or requirements of marketplace. On the other hand, the supply flexibility considers the flexibility of upstream network of supplier and is attributed with flexible supply contracts, collaborative supplier associations, and supply base.

In general, supply chain flexibility is thought to be a competitive response (Venkatesh *et al.*, 2015) to environmental uncertainty and the optimization of material flow using complex supply chain networks. This shows that supply chain flexibility must help organizations to mitigate risks that comes from environmental uncertainty. However, several studies (Wu *et al.*, 2017) have exhibited that the association between organizational structure and environment is essential for improving organizational performance. Particularly, studies have repeatedly emphasized upon the need to develop a model among supply chain flexibility and uncertainty to assess organizational and operational performance. Therefore, we declare that organizations that put their environmental uncertainty in order with supply chain flexibility can easily mitigate the risks as compared to the organizations which do not align their supply chain flexibility with uncertainty. So, supply chain risk has been classified into three components i.e. delivery risk, manufacturing risk, and supply risk. Furthermore, we have also identified the manufacturing flexibility, logistics or distribution flexibility, and supply flexibility which could facilitate in mitigating the components of respective SCR.

The literature review of supply chain has shown that increasing uncertainty under SC and rapidly growing market competition compel firms to develop a collaborative relation among the suppliers and to make flexible supply agreements (Kwak *et al.*, 2018). Furthermore, the effective supplier association is an important factor in supply flexibility, increasing the responsiveness of organization towards changing material needs and improves the suppliers' willingness in sharing the

level of risk under uncertain environments (Lo and Power, 2010). Moreover, it is evident from the literature that supplier involvement for design modifications and product development plays a significant role in resolving supply failures that results from lead-time problems under uncertain situations. Supply flexibility through flexible supply assists in the process of minimizing risks arising from supply shortages in a case where supplier is unable to supply because of product uncertainty. For efficient manufacturing of assorted products, organizations are required to enhance their process flexibility through adoption of flexible manufacturing operations. Numerous research studies have highlighted the need for various dimensions related to manufacturing flexibility against environmental uncertainty, for effectively minimizing the adverse effects of uncertainty. As mix flexibility reduces the level of uncertainty to satisfy customer needs in terms of product features and performance, contrarily, the volume flexibility reduces the level of uncertainty in quantity that is going to be delivered by allowing organizations to produce the required product demanded by the customer.

In a similar manner, organizations with flexible logistics and distribution system shows greater SC agility, that is modification of order delivery schedules and delaying commitment in order to handle ever-changing and unforeseen customer needs (Srinivasan *et al.*, 2011; Edwin *et al.*, 2017; Durie and Beshir, 2018; Eketu, 2018). Furthermore, adopting distribution flexibility is considered to be essential for greater responsiveness and adaptability in response to uncertain demands of markets therefore facilitates firm in minimizing the delivery risks. On the basis of above discussion, the following hypotheses are proposed:

H4. Supply flexibility (SF) acts as a moderator in the relationship among supply risk (SR)and environmental uncertainty (EE).

H5. Manufacturing flexibility (MF) acts as a moderator in the relationship among manufacturing risk (MR) and environmental uncertainty (EE).

H6. Logistics/distribution flexibility (LF) acts as a moderator in the relationship among delivery risk (DR) and environmental uncertainty (EE).

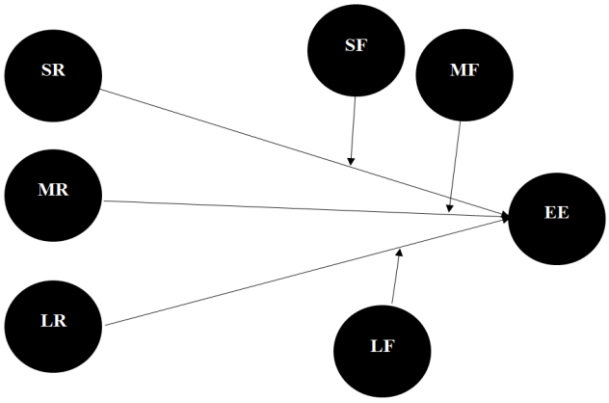

Figure 1: Conceptual framework

METHODOLOGY

The present study employed a survey method, the most common method for obtaining primary research data, particularly in the case of business research. The research used two means for data collection i.e. through email and self-administered questionnaires. A cover letter highlighting the research objectives and expected responses, is attached with each survey that are delivered through email. Whereas, each respondent is directly briefed about the study objectives during the data collection process. SPSS 19 was used for analyzing and performing quantitative analysis on the data. Descriptive analysis is performed for compiling and interpreting the collected responses, which were then processed into a more compact form. In addition, various statistical tests are performed including correlation, multiple regression, and frequency distribution. Testing of hypotheses were done using multiple regression analysis and Pearson correlation coefficient test, exhibiting the direction as well as the degree of strength among independent and dependent variables. They also identify the most significant variable in the model. Pallant suggested that the relation among the variables of the model can be calculated by analyzing its value which lies between -1 to 1. In addition, it also suggests the degree of association between the variables, where 1 represents perfect positive association and -1 represents perfect negative association among the variables.

RESEARCH ANALYSIS AND DISCUSSION

The initial step in data analysis is to determine the validity of the employed instrument. For this purpose confirmatory factor analysis is employed. Following the rule of thumb, that factor loadings must exhibit higher values i.e. above 0.50 to be acceptable. Therefore, the sample size for the present study is taken as 276, for obtaining the factor loadings for the association among factor loading and sample size. The loadings for each item of this study turned out to be above 0.40, because of the appropriate sample selection.

Several authors have suggested that the normal sample size range is 30-150, indicating that greater the sample size the higher the data normality. The data normality improves as the sample size gets larger and larger. Afterwards, a normality test is performed for analyzing the data normality (Hafeez et al., 2018). A multicollinearity test indicates the correlation among all the variables. Therefore, it is assumed that all the explanatory variables are expected to show any relation with the dependent variable. Although, such relationship or correlation must not be higher enough to exhibit multicollinearity in the data. Thus, multicollinearity is the higher degree of correlation among the independent variables that are involved in the study. Collinearity explains a condition in which some of the independent variables of a model are found to be highly correlated with each other. Researchers are required to avoid the multicollinearity problem, since it can influence the data analysis through providing misleading results and impractical interpretations about the findings. Therefore, multicollinearity test was performed through regression analysis. The results showed no multicollinearity of data.

In any research, non-response bias can also occur, due to various reasons. Such as, due to fear of top management, lack of enough time, sensitive nature of questions, inability of reaching out the potential respondents, failure of providing meaningful responses, or lack of cooperation. The appropriate selection of the respondents must be ensured to avoid non-response bias. In addition, questionnaires must be well-arranged and clearly addressed while developing the questionnaire. Poorly handled or incomplete questionnaires must be discarded at an early stage of data assembling.

Table 1. Reliability

	CR	AVE	Cronbach Alpha
SR	0.975	0.872	0.885
MR	0.702	0.737	0.924
LR	0.960	0.871	0.893
SF	0.802	0.832	0.916
MF	0.923	0.802	0.865
LF	0.832	0.707	0.824
EE	0.940	0.801	0.854

Factor analysis, a commonly used test for construct validity, which is performed to summarize or minimize data in order to improve its straightforwardness, visibility, and manageability, thus highlighting the suitable items for each of the dimension. Two important issues i.e. interconnectedness between the items, and sample size must be considered while performing the factor analysis. Therefore, an adequate sample size i.e. above 150 must be used to perform factor analysis. Bartlett's Sphericity test is also performed to assess the interconnectedness among the items. The value for sphericity test must be significant at $p < 0.5$. Cronbach alpha coefficient is one of the common estimates for measuring the scale reliability. It shows the internal consistency of the model. The Cronbach alpha result for present study indicate above 80 % values for each construct, which are in line with the previous research. Thus, no reliability problem exists in this study. Afterwards, multiple regression analysis is employed for testing of hypotheses. Table 3 shows the direct relations between the variables.

Table 2. Direct Effect

	(β)	SD	T-value	P-Values
H1	0.211	0.135	3.211	0.000
H2	0.357	0.152	3.678	0.000
H3	0.321	0.178	3.321	0.000

The indirect effect of the current study are shown in table 4.

Table 3. Indirect Effect

	(β)	SD	T-value	P-Values
H4	0.211	0.135	3.211	0.000
H5	0.342	0.165	3.234	0.000
H6	0.453	0.187	3.768	0.000

Through R2 value, the predictive power can be analyzed for the endogenous variables. The variables near to 0 are considered non-significant. High predictive accuracy is reflected by the value of R2 in the range of 0-1. The values of R2 such as 0.75, 0.50 and 0.25 are considered considerable, fair and weak respectively. In this research study, the value of R2 comes out to be 0.290, which reflects that almost 29 percent variation in EE is defined, by the environmental uncertainties and integration of green supply chain.

Table 4. Expected Variance

	R^2
EE	29.0 %

CONCLUSION

This study aims to address the existing research gap, as well as to explore the various types of flexibility which could contribute in mitigating supply chain risks. In this regard, we consider three aspects under SCR namely; manufacturing process risk, delivery risk, and supply risk. The study explores the relationships among supply chain risk and environmental uncertainty, and the moderating role of supply chain flexibility by employing data of 91 manufacturing companies and develop a structural equation modelling. Developing economies are contributing well in the global trade and are responsible for 50% of the generated global output. They present future prospects for economic growth and pose challenges mainly because of immature supply chain operations. Considering the critical role of emerging economies in global supply chain, such as India and China, it is also important to observe the moderating and driving supply chain risk factors in these regions. It is assumed that this study will not only fill the existing gap in the literature of SCRM but will assist researchers and practicing managers, by enabling them to fully understand certain types of supply chain flexibility, thus reducing the SCR under business environments. Frequent technological changes in production increases manufacturing complexity and drive technical alterations on the suppliers' side. Furthermore, substantial variations in order size can result in frequent changes in the production as well as in the production mix and volume of suppliers' production. Therefore, according to supply uncertainty is referred as the unmanageable and unforeseeable factors in the material flow that are predominantly characterized as the manufacturing variability in volume, product mix, and technological complexity. Therefore, the study is among the pioneering studies on the issues. So, the current study has used SEM-PLS as a statistical tool to answer the research questions raised in this study and research objectives envisaged in the current study. The findings of the current study have shown agreement with proposed findings.

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