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SUPPLY CHAIN COMPETENCY AND ITS EFFECT ON PERFORMANCE: A FUZZY-SET ANALYSIS

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ABSTRACT

With organizations concentrating on their core competencies, the role of suppliers and supply chain management has assumed greater importance. The objective of this study was to come up with a composite variable of supply chain competency (SCC) based on different constituent factors, namely, supplier involvement, length of supplier relationship, use of IT, and logistics integration and to analyze its relationship and that of the individual factors with a firm's supply chain performance (SCP). Survey data was collected from 187 organizations in Brazil, Korea and India. Fuzzy-set methodology was employed to determine causation i.e., whether SCC and other factors were necessary or sufficient cause for SCP. The findings indicate that SCC is both a necessary and sufficient cause for SCP which establishes its importance as an explanatory variable for SCP.

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KEYWORDS: Supply Chain Competency, Supply Chain Performance, Fuzzy-Set Analysis

INTRODUCTION

Increased competition in a globalized market place has resulted in most organizations focusing on their core competencies and outsourcing other activities to their suppliers and business partners, both upstream and downstream in the value chain (Prahalad and Hamel, 1990). Added reliance on suppliers has transformed competition between individual firms to competition between supply chains (Anderson and Katz, 1998). The source of competitive advantage is no more localized in the focal organization but is dispersed along the entire supply chain. This has led to a greater internationalization of sourcing, production and manufacturing activities, adding to the complexity of supply chains. Management of supply chains has thus become increasingly important as a potential source of competitive advantage and improved performance.

Critical to the concept of supply chain management (SCM) is the notion of collaboration and integration among business partners. Organizations are called upon to collaborate extensively so that the entire process across the supply chain can be managed as a unit where each member of the supply chain focuses on what it does best leaving the rest to others (Prahalad & Hamel, 1994). Though the extent of interaction is determined by the level of integration desired, management of supply chain processes necessitates multiple communications at different decision levels leading to lower inventories, reduction in cycle time, improved quality and better customer service (Davis, 1993). Furthermore, companies high on the integration level do not limit their collaboration to operational issues alone. They fully realize the benefit of outsourcing through increased involvement in joint product design and development, and other allied activities. The objective of this study was to determine the relationship of different constituent factors of supply chain to performance. Four factors, namely, supplier involvement, longer supplier relationship, better use of information and communications technology, and closer logistics integration were deemed as

critical to supply chain efficacy and have been used as influencing variables. Further, the study develops a holistic variable, Supply Chain Competency (SCC), based on these factors to capture the overall competency of the supply chain. Similarly, a variety of measures were used to determine the overall performance of the supply chain, called, Supply Chain Performance (SCP). The study was limited to manufacturers and suppliers i.e., it focuses on the upstream segment of the supply chain. Unlike most studies of this nature which have been conducted in developed countries, this study was carried out in three developing countries. A distinctive feature of the study uses is that it uses the Fuzzy-set methodology for analysis. This methodology has possibly never been employed for studies of this nature. In next section, the theoretical justification for the variables used in the study is discussed and hypotheses proposed. After that the research methodology and data collection is described. This is followed by analysis and discussion of results. Finally, conclusions are presented.

LITERATURE REVIEW OF SUPPLY CHAIN FACTORS

Improving service levels, reducing costs, and more efficiently responding to changes in customer demand are important supply chain goals. Based on literature survey, four factors, namely, supplier involvement (Ragatz, Handfield, and Scannell, 1997, Shin, Collier, and Wilson, 2000, Primo and Amundson, 2002), length of supplier relationship (De Toni and Nassimbeni, 1999, Dyer, 1997), use of information and communications technology (Radstaak and Ketelaar, 1998, Karoway, 1997), and logistics integration (Morash, Droge, and Vickery, 1997, Stock, 1990,) were identified as variables affecting SCP. Chen and Paulraj (2004) in their detailed analysis of supply chain management research have also included these factors as critical elements having a significant impact on SCP. The individual factors are discussed below.

Supplier Involvement (SI)

With companies outsourcing not only commoditized products but even fabrication and sub-assemblies, an ever increasing value of the end product value is being contributed by suppliers. Supplier involvement is hence critical to management of different supply chain processes. The recognition that inter-firm resources and relationships in which the firm is embedded can be a potential source of competitive advantage for all partners in a supply chain highlights the importance of increased supplier involvement (Hamel, 1991, Khanna, Gulati, and Nohria, 1998). Overall, a high degree of supplier involvement results in optimization of the resources and capabilities of the entire supply chain and has been found to be an important determinant of supply chain performance (Shin, Collier, and Wilson, 2000). Meaningful supplier involvement requires long-term commitment from the supplier and purchasing organizations and appropriate technological preparedness. Organizations profit by closer interaction with their suppliers for a variety of activities. Suppliers can learn about customer requirement and preferences leading to a better application of resources. Supplier involvement in activities such as product design, continuous improvement and other collaborative efforts positively affect performance (Vonderembse and Tracy, 1999, Clark, 1989, Lavie, 2006). Mechanisms and procedures facilitating early supplier involvement can lead to a reduction in design and manufacturing costs, and in the risks associated with supply disruption. Supplier involvement is especially beneficial to the product development process (Ansari and Modarress, 1994). Creation of cross-functional teams and participation of the focal organization and suppliers in the product development process can lead to higher product development productivity and a reduction in the time-to-market of new products (Shin, Collier, Wilson, 2000).

Length of Supplier Relationship (LSR)

With the increasing acceptance of core competency as an operating practice leading to vertical disintegration, firms must necessarily augment their supplier relationships. Strong supplier relationships helps better leveraging of resources and capabilities across the supply chain resulting in better satisfaction

of customer needs. Additionally, supplier relationships also facilitate logistics integration which is so crucial to overall supply chain performance (Paulraj and Chen, 2007). Given complex supply networks, collaboration among members of the supply chain undoubtedly poses a logistical challenge. However, the biggest impediment to collaboration arises from the lack of complete trust between participating organizations. The importance of trust and its lack thereof leading to opportunism is well established in the transaction theory of Williamson (1975). Existence of trust is necessary to transform transactional relationships to a collaborative ones and lay the foundation for successful alliances (Monczka *et al.,*1998, Whipple and Frankel, 2000, Zhao and Cavusgil, 2006). While trust helps build relationships, length of the relationship in turns augments trust and the strength of the relationship is determined *inter alia* by the relationship's overall duration (Capaldo, 2007). Collaborative relationships are generally typified by long term relationships (Min *et al.,* 2005, Ogden, 2006). Long term relationships strengthen buyer-seller relationships (Stuart, 1993), enables a supplier to become an integral part of a supply chain which has a lasting effect on the competitiveness of an entire supply chain and leads to better supply chain performance (Shin, Collier, and Wilson, 2000).

Information Technology (IT)

To address the increasing complexity of supply networks, organizations use a variety of IT tools to further integration. IT enables sharing of information leading to higher visibility among supply chain members with attendant benefits of reduced inventory and supply disruptions. It can aid a host of activities and processes such as production planning, inventory management, order fulfillment, shipment status etc. Use of IT reduces transaction costs along the entire supply chain and helps eliminate the inefficiencies of a supply chain. It facilitates inter-organizational collaboration, improves flexibility and responsiveness (Swafford, Ghosh, and Murthy*,* 2008, Gunasekaran and Ngai, 2004), and leads to better overall supply chain management and performance (Kearns and Lederer, 2003, Vickery *et al.,* 2003, Stank, Keller, and Daugherty*,* 2001, Radstaak and Ketelaar, 1998, Karoway, 1997).

Logistics Integration (LI)

The term integration encompasses both internal and external. External integration i.e., the integration of processes across business partners of the supply chain is especially desired as most firms are moving away from an adversarial relationship to more of an alliance characterized by a long term relationship with a fewer number of suppliers (Ogden, 2006). A necessary pre-requisite for such integration is for the focal organization to view suppliers as strategic partners who can add value and be a source of competitive advantage (Langley and Holcomb, 1992, Chen and Paulraj, 2004).

Within the overall ambit of integration, logistics integration specifically, calls for increased sharing of logistics related information leading to better coordination of all logistics activities among the focal organization, suppliers and customers (Stock, Greis, and Kasarda, 2000). It is premised on the belief that the value proposition to the customer is enhanced when the logistics activities are coordinated so that products and information can flow seamlessly through the entire supply chain. Logistics integration can eliminate waste from the supply chain, lead to smoother production processes (Frohlich and Westbrook, 2001), improve flexibility and responsiveness, and reduce cost of doing business (Nooteboom, 1992). It has been found to be among the most important of all supply chain factors in its impact on performance (Narasimhan and Kim, 2002, Tan, 2002).

Supply Chain Competency (SCC)

Important as they may be, individual variables of supply chain management, as discussed above, may not make an impact on supply chain performance. Supply chains are multi-dimensional in nature and hence improvements in supply chain performance are more likely to result from the combined effect of these

factors. The process view of organizations emphasizing horizontal processes cutting across organizational boundaries, which underpins the concept of supply chains, lends support to the notion of a holistic variable. A holistic variable, as a measure of supply chain competency, is really a characteristic of the integration of supply chain participants (Chen, Daugherty, and Landry, 2009, Fawcett, Magnan, and McCarter, 2008, Kim, 2006). For the purpose of this study, this holistic variable, SCC, represents the four different variables (SI, LSR, LI, IT) working in concert. A higher SCC value suggests higher efficiency of operations across the supply chain resulting from better collaboration and integration among supply chain members and would be a source of competitive advantage (Bowersox, Closs, and Stank, 2000, Christopher, 2011, Lambert and Cooper, 2000, Lee, 2004, Ketchen et al. 2008, Mentzer et al., 2001). SCC therefore, will have a positive impact on performance.

Various theoretical approaches lend support to the variables used in the study. Individual variables, such as IT for example, help lower transaction cost and hence find support from the transaction cost perspective (Coase, 1937, Williamson, 1975). The "relational view" of inter-organizational competitive advantage (Dyer and Singh, 1998) lends support to the importance of supplier relationship as factor impacting supply chain performance (Autry and Griffis, 2008, Cousins and Menguc, 2006, Staughton and Johnston, 2005). Similarly, an extended view of the resource-based view (Barney, 1991) provides theoretical foundation for the concept of supplier involvement. Supplier involvement augments the resources and capabilities of the focal organization and helps in the innovation process through external exchange (Capron, Dussauge, and Mitchell, 1998).

METHODOLOGY

Fuzzy-set Analysis (FSA) methodology was used in this study. The methodology was developed by Ragin (1987, 2000). The objective of FSA is to determine the relationship between the variable of interest (in our case, supply chain performance) and other variables. Specifically, it helps identify necessary and sufficient conditions for the outcome of interest i.e., SCP. The uniqueness of FSA stems from the fact that it combines both qualitative and quantitative aspects in a single methodology. Variables in fuzzy set analysis are conceptualized as qualitative states i.e., as sets with boundaries between membership and non-membership. A value of 1 represents complete membership while a value of 0 represents non-membership. These two scores reflect the two qualitative states of being *fully in* and *fully out, also referred to as the "crisp set"*. Variables however, may have intermediate scores between these two end values and this is what introduces the quantitative element in the methodology. The extent or degree of membership in the set is determined by the score. The scores between these end points inject the quantitative element in the methodology. Individual instances in fuzzy-set analysis vary in the degree of their membership in these states. It is this concept of partial membership which distinguishes it from the crisp set. A score of 0.5 suggests half membership i.e., the case is neither in nor out. A score higher than 0.5 indicate that case is more in than out, while a score below 0.5 indicates that case is more out than in (Ragin, 2000). FSA employs the subset principle to determine causation.

For a variable to be considered a necessary cause, the fuzzy-set scores of the causal variables (Xi) must be equal to or greater than fuzzy-set score of the outcome variable (Yi) i.e., the outcome is a subset of the causal factor ($Yi \leq Xi$). Inference of sufficient causation on the other hand requires that the fuzzy-set scores of the causal variables be less than or equal to the score of the outcome variable i.e., the causal factor is a subset of the outcome ($Xi \leq Yi$). To enhance the utility of the technique since strictly necessary and sufficient conditions may not be realized in actual conditions, Ragin (2000) has proposed the concept of "quasi-necessity" and "quasi-sufficiency" through the use of adjustment factors. Using an adjustment factor of 0.17 implies that the necessary causation condition would be satisfied if $Yi - 0.17 \leq Xi$ and a sufficiency causation would be satisfied if $Xi - 0.17 \leq Yi$. Furthermore, since even a single inconsistent data point will invalidate the inference of necessary or sufficient causation, researchers have often used benchmark proportions (Pennings, 2003). A benchmark refers to the proportion of the cases

that are consistent with the causal argument being tested. A factor is considered "almost always" necessary (or sufficient) if 80 % or more of the cases exhibit the causal relationship and "usually" necessary (or sufficient) if 65 % or more of cases are consistent with the causal argument (Ragin, 2000).

HYPOTHESES

Based on the above discussion of supply chain factors and the methodology employed in the study, the following hypotheses are proposed.

Hypothesis 1: SCC is an "almost always" necessary cause for SCP
Hypothesis 2: SCC is an "almost always" sufficient cause for SCP
Hypothesis 3: SI is a necessary cause for SCP
Hypothesis 4: LSR is a necessary cause for SCP
Hypothesis 5: IT is a necessary cause for SCP
Hypothesis 6: LI is a necessary cause for SCP

It is important to note that SCC, a composite variable which captures the aggregate effect of the individual factors, is hypothesized as both a necessary and sufficient cause for SCP. Individual variables on the other hand are only expected to be necessary but not sufficient causes for SCP. Each variable by itself is a necessary pre-requisite for SCP but on its own cannot ensure SCP. Only in conjunction with other variables will it be result in SCP. Further, since the primary variable of interest of the study is SCC, hypotheses relating to SCC are being tested for "almost always" validity i.e., they will be tested at the test proportion of 0.80.

DATA COLLECTION

Sampling and Data Collection

The survey was done in three countries, Brazil, Korea, and India. The survey in Brazil was done in 2010 while that in Korea and India were done in summer and fall of 2011. A total of 60 personal interviews were conducted in 4 states of Brazil. The survey in India was essentially restricted to the eastern part of India. Out of a total of 220 companies who were contacted, 60 agreed to fill up the questionnaire in personal interviews. For the survey in Korea, the survey instrument was first translated in Korean and then mailed to 80 firms. A total 67 completed questionnaires were received. No obvious pattern was observed relating to the 13 non-respondents. Since the entire process of mailing and receiving the questionnaire was completed within two months it suggests little, if any, early response bias.

A wide spectrum of industries was represented in the survey. Major sectors represented in the survey were automotive (17%), consumer durables (16%), electrical equipment (19%) and chemical (16%). Table 1 gives the industry wise composition of surveyed organizations. Firms of different sizes were represented in the sample and the respondents were senior managers in the logistics/supply chain management department of the organizations who had spent considerable time in their companies and had adequate knowledge of its operations.

Items and Scales

A structured questionnaire employing 7-point Likert-type scale was used to collect data. Most of the items were adapted from earlier studies ensuring content validity (Chen and Paulraj, 2004, Bhatnagar and Sohal, 2005). Multi-item scales for different supply chain factors were developed and pretested prior to finalization of the survey instrument. While a host of measures have been employed to determine SCP (Christopher, 1998, Stewart, 1995, Mapes, New and Szwejczewski, 1997, Davis, 1993, Van Hoek, 2001),

literature suggests that there is a lot of commonality in the measures used. Measures used to study SCP for this research were restricted to operational measures alone such as quality, delivery and flexibility (Vickery, DrÖge and Markland, 1993, Miller and Roth, 1994). Specifically, SCP was measured by flexibility (volume and scheduling flexibility), on-time delivery, delivery reliability, quality standards, order lead time and order fill rate.

Table 1: Industry Wise Composition of Surveyed Companies

	Brazil	Korea	India	Total
Automobiles/Components	20	8	3	31
Fast moving consumer goods	7	5	8	20
Consumer Durables	22	7	0	29
Electrical equipment/machinery	9	25	2	36
Engineering goods	0	1	5	6
Chemicals/Pharmaceuticals	2	12	16	30
Other	0	9	26	35
Total	60	67	60	187

This table shows the composition of surveyed companies.

Analysis and Discussion of Results

Responses for survey items for the different supply chain factors, namely, LSR, LI, SI and IT, were tested for convergent reliability and discriminant validity using PLS software. Cronbach's alpha value of 0.7 is considered acceptable for convergent reliability. All values were above 0.8 suggesting good reliability for the individual constructs of the supply chain factors. SCP is viewed as a formative construct and hence the test for convergent reliability does not apply (Diamantopoulos and Winklofer, 2001). Discriminant validity indicates the extent to which items of a construct differ or discriminate from items of another construct. The results of discriminant validity test clearly indicated that the constructs share a larger variance with their own indicators than with another construct. Discriminant validity is thus clearly established. Once again the issue of discriminant validity for SCP is inapplicable because of the formative nature of SCP construct. To come up with a single measure of SCP a principal component analysis (PCA) was conducted. SCP was computed by doing a PCA on the different performance variables (volume flexibility, scheduling flexibility, on-time delivery, quality standards, order lead time and order fill rate). A single factor based on the Eigen value criterion was retained.

This single measure captured most of the variation and hence was reflective of the overall performance. Similarly, to compute SCC, a PCA was performed on its constituent variables, namely, LSR, LI, SI and IT which resulted in a single factor being retained. Based on the individual values for variables, SCC and SCP for each respondent, fuzzy-set scores were assigned to each value using a seven-value fuzzy-set (1, 0.83, 0.67, 0.5, 0.33, 0.17 and 0). A seven value fuzzy set has been used by many authors as it permits a "relatively fine-grained distinction between cases" (Katz, Hau, and Mahoney, 2005). Fuzzy-set data was then analyzed to determine necessary or sufficient causation between SCC, the primary variable of interest, and SCP. The relationship of the constituent variables of SCC, namely, LSR, LI, SI and IT with SCP was also examined. As noted earlier, the use of adjustment factor of 0.17 has been recommended by Ragin (2000) since absolutely necessary or sufficient causes are seldom realized. An adjustment factor was employed in cases, if required.

Inference of a necessary or sufficient cause is best made using a test proportion of 0.80. A test proportion of 0.80 indicates that the factor is "almost always" necessary or "almost always" sufficient for the outcome. According to literature however, a test proportion 0.65 which suggests that the factor is "usually" necessary or "usually" sufficient for the outcome can also be considered. Clearly, a test proportion of 0.65 indicates a weaker causation than 0.80. In this study, analysis was done for both proportions and the results are discussed below.

Analysis of Necessary Causes

Table 2 presents the results of the analysis of necessary causes. The results clearly support the hypotheses. The table indicates, for example, that in 97 % of the cases the fuzzy score of LI was greater than the fuzzy score of SCP. When tested for significance at 0.8 this proportion was found to be significant at 0.01 level which leads to the conclusion that LI is almost always necessary for SCP. Similarly, in 82 % of the cases the adjusted value of SI (using an adjustment factor of 0.17) was more than SCP. This proportion was found to be significant when tested at test proportion of 0.65 which leads to the conclusion that SI is usually necessary for SCP. To sum up the results, as hypothesized, SCC is almost always necessary for membership in SCP. Of the constituent factors of SCC, while LI and LSR are almost always necessary, SI and IT are usually necessary for the outcome to happen. Thus, all the factors individually are either almost always or usually necessary for SCP. In other words, in the absence of these factors it is unlikely that an organization would be able to excel at SCP.

Table 2: Necessary Causes (Combined Dataset of All Countries)

	Proportion of Cases: Cause ≥ SCP	
Causal Factor	Almost Always Necessary (Tested at proportion of 0.8)	Usually Necessary (Tested at proportion of 0.65)
SCC	0.90*** (adj.[1])	
Logistics Integration	0.97***	
Supplier Involvement		0.82*** (adj.[1])
Length of Supplier Relationship	0.89***	
Use of IT		0.75***

****p<0.01; **p<0.05; *p<0.1; 1: an adjustment factor of 0.17 was used. Figures in the table indicate the proportion of cases where the causal factor value was equal or greater than the SCP value*

Next necessary analysis for individual countries was performed. These are reported in Tables 3 through 5. In the case of Brazil (Table 3), the adjusted value of SCC was found to be greater than SCP in 88 % of the cases and this proportion turned out to be significant when tested at a proportion of 0.8. This leads to the inference that SCC is almost always necessary for SCP. The individual variables, except for SI, turn out to be almost always necessary. SI turned out to be usually necessary. The results for Brazil were very similar to those for the combined dataset.

Table 3: Necessary Causes (Brazil

	Proportion of Cases: Cause ≥ SCP	
Causal Factor	Almost Always Necessary (Tested at proportion of 0.8)	Usually Necessary (Tested at proportion of 0.65)
SCC	0.88* (adj.[1])	
Logistics Integration	1***	
Supplier Involvement		0.75*
Length of Supplier Relationship	0.90***	
Use of IT	0.98***	

****p<0.01; **p<0.05; *p<0.1; 1: an adjustment factor of 0.17 was used. Figures in the table indicate the proportion of cases where the causal factor value was equal or greater than the SCP value.*

Table 4 presents the results for India. It shows, for example, that in 93 % of the cases the adjusted value of SCC was greater than SCP. This turned out be significant at 0.01 level when tested at the almost always necessary proportion of 0.8. Similarly, LI turned out to be almost always necessary, while LSR and IT were found to be usually necessary. However, SI did not turn out to be necessary either at the 0.8 or 0.65 levels.

Table 4: Necessary Causes (India)

Proportion of Cases: Cause ≥ SCP		
Causal Factor	Almost Always Necessary (Tested at proportion of 0.8)	Usually Necessary (Tested at proportion of 0.65)
SCC	0.93***(adj.[1])	
Logistics Integration	0.98***	
Supplier Involvement		0.71 (adj.[1])
Length of Supplier Relationship		0.85***
Use of IT		0.85***(adj.[1])

****p<0.01; **p<0.05; *p<0.1; 1: an adjustment factor of 0.17 was used. Figures in the table indicate the proportion of cases where the causal factor value was equal or greater than the SCP value.*

Results of the necessary analysis on the Korean organizations are shown in Table 5. It shows that in 89 % of the cases the adjusted value of SCC is greater than SCP and this turned out to be significant at the test proportion of 0.8 i.e., it is almost always necessary. Similarly, LI and LSR turned to almost always necessary while SI and IT were found to be usually necessary.

Table 5: Necessary Causes (Korea)

Proportion of Cases: Cause ≥ SCP		
Causal Factor	Almost Always Necessary (Tested at proportion of 0.8)	Usually Necessary (Tested at proportion of 0.65)
SCC	0.89**(adj.[1])	
Logistics Integration	0.94***	
Supplier Involvement		0.79***
Length of Supplier Relationship	0.94***	
Use of IT		0.80***

****p<0.01; **p<0.05; *p<0.1; 1: an adjustment factor of 0.17 was used. Figures in the table indicate the proportion of cases where the causal factor value was equal or greater than the SCP value*

To sum up, the results on the combined dataset were largely replicated in the case of the three individual countries i.e., all the variables were found to be almost always or usually necessary except for SI in the case of India.

Analysis of Sufficient Causes

Table 6 presents the results of the analysis of sufficient causes. 93 % of the adjusted SCC values were less than the SCP values and this turned out to be significant at the test proportion of 0.8. Thus, as hypothesized, SCC is almost always sufficient for SCP. In other words, SCC essentially guarantees SCP. However, only 61 % and 69 % of the adjusted values of LI and LSR respectively were less than SCP and when tested at the test proportion of 0.65, these turned out be not significant. SI was found to be almost always sufficient while IT was usually sufficient. It is clear that while SCC by itself is sufficient to ensure SCP, the same is not true of all its constituent variables. This is fully consistent with the underlying logic of SCC as a measure of the overall competency of the supply chain. Individual variables, important as they may be, represent only a particular dimension of supply chain functioning and do not therefore, ensure overall performance.

Table 6: Sufficient Causes (Combined Dataset of All Countries)

	Proportion of Cases: Cause ≤ SCP	
Causal Factor	Almost Always Sufficient (Tested at proportion of 0.8)	Usually Sufficient (Tested at proportion of 0.65)
SCC	0.93*** (adj.[1])	
Logistics Integration		0.61(adj.[1])
Supplier Involvement	0.88*** (adj.[1])	
Length of Supplier Relationship		0.69 (adj.[1])
Use of IT		0.74*** (adj.[1])

****p<0.01; **p<0.05; *p<0.1; 1: an adjustment factor of 0.17 was used.*
Figures in the table indicate the proportion of cases where the causal factor value was less than or equal to the SCP value

Next, separate analysis for each country was carried out (Tables 7 through 9). SCC which was almost always sufficient in the combined dataset again turns out to be almost always sufficient in case of each country which testifies to the robustness of the result. In the case of Brazil (Table 7), 91 % of the SCC values were less than SCP while the values for India (Table 8) and Korea (Table 9) were 90 % and 97 % respectively. When tested for significance these values turned out to be significant leading to the inference of SCC being almost always sufficient. Besides SCC though, in the case of Brazil (Table 7), only SI turned out be significant at the 0.65 level. LI, LSR and IT failed the sufficiency test.

Table 7: Sufficient Causes (Brazil)

	Proportion of Cases: Cause ≤ SCP	
Causal Factor	Almost Always Sufficient (Tested at proportion of 0.8)	Usually Sufficient (Tested at proportion of 0.65)
SCC	0.91**(adj.[1])	
Logistics Integration		0.56 (adj.[1])
Supplier Involvement		0.75* (adj.[1])
Length of Supplier Relationship		0.60 (adj.[1])
Use of IT		0.60 (adj.[1])

****p<0.01; **p<0.05; *p<0.1; 1: an adjustment factor of 0.17 was used. Figures in the table indicate the proportion of cases where the causal factor value was less than or equal to the SCP value.*

Table 8 shows the results of the analysis for India. With the exception of LI, all the other variables, namely, SI, LSR and IT were significant when tested at the test proportion of 0.65. They are hence termed as usually sufficient. With respect to LI, however, only 61 % of the values were less than that of SCP which was not enough to meet the sufficiency condition.

Table 8: Sufficient Causes (India)

	Proportion of Cases: Cause ≤ SCP	
Causal Factor	Almost Always Sufficient (Tested at proportion of 0.8)	Usually Sufficient (Tested at proportion of 0.65)
SCC	0.90**(adj.[1])	
Logistics Integration		0.61 (adj.[1])
Supplier Involvement		0.85***
Length of Supplier Relationship		0.80*** (adj.[1])
Use of IT		0.86***

****p<0.01; **p<0.05; *p<0.1; 1: an adjustment factor of 0.17 was used. Figures in the table indicate the proportion of cases where the causal factor value was less than or equal to the SCP value.*

Table 9 shows the results for Korea. In addition to SCC, SI turned out to be almost always sufficient cause (91 % of cases had values less than SCP). Among the other constituent variables, LSR and IT turned out to be usually sufficient while LI did not turn out to significant either at 0.8 or 0.65 test proportion. To summarize, the analysis of the individual countries reveals that, as in the combined dataset, while SCC is almost always sufficient for SCP, individual variables on their own are generally not sufficient for SCP.

Table 9: Sufficient Causes (Korea)

	Proportion of Cases: Cause ≤ SCP	
Causal Factor	Almost always Sufficient (Tested at proportion of 0.8)	Usually Sufficient (Tested at proportion of 0.65)
SCC	0.97*** (adj.[1])	
Logistics Integration		0.64 (adj.[1])
Supplier Involvement	0.91** (adj.[1])	
Length of Supplier Relationship		0.76** (adj.[1])
Use of IT		0.77** (adj.[1])

****p<0.01; **p<0.05; *p<0.1; 1: an adjustment factor of 0.17 was used. Figures in the table indicate the proportion of cases where the causal factor value was less than or equal to the SCP value.*

CONCLUSION & IMPLICATIONS

The primary motivation of the study was to analyze the relationship between the factors of supply chain with performance. This is especially relevant in an age where outsourcing is commonplace and success of organizations is often determined by success in managing supply chains. Data for the study was collected through a structured survey instrument from 187 respondents in three countries, namely, Brazil, India and Korea. Single measures of overall supply chain competency and performance were developed by employing PCA on their constituent factors. Fuzzy-set methodology was then employed to analyze the data and determine the existence of necessary or sufficient causation between SCC and SCP. The strength and appropriateness of the fuzzy-set approach to this study lies in the fact that it combines qualitative and quantitative aspects in its analysis. Variables are viewed as qualitative states and are assigned values between 0 and 1. Unlike regression, FSA does not treat all variation as relevant which makes the methodology suitable for analyses such as this. Using FSA, when a variable is determined to be a necessary cause, it implies that outcome will never occur in the absence of the cause. To put it differently, whenever the outcome is present, the cause will also be present; the cause therefore, is viewed as a *sine qua non* for the outcome. Determination of a sufficient cause on the other hand suggests that whenever the causal factor is present, the outcome will also be present.

Analysis on the combined dataset suggests the SCC is an almost necessary cause for SCP (hypothesis 1). For an organization to perform well it must possess adequate SCC. Further, since all the individual factors also turned out be necessary causes, hypotheses 3 through 6 are met. It suggests that individual factors are also essential for SCP. The findings were largely, though not completely, replicated in the case of individual countries. This testifies to the robustness of the results for it suggests that the findings are valid across different countries and organizational and cultural environments. Analysis of sufficiency analysis on the combined dataset reveals that SCC is an almost sufficient cause for SCP (hypothesis 2). The presence of SCC thus ensures SCP. The dual determination of SCC both as a necessary and sufficient cause suggests that while SCC is necessary for SCP, its presence also guarantees SCP. The importance of SCC as an explanatory causal variable of SCP is thus fully established. Interestingly, two of the individual variables failed to meet the sufficiency condition. This suggests that more than the individual constituent variables of SCC, what is crucial for SCP is the overall competency of the supply chain i.e., SCC. The results provide empirical support to the notion of SCC and for its utility as an explanatory variable for SCP. An organization lacking in a particular dimension of supply chain competency may make up for its deficiency by scoring high on another dimension. It is the overall supply chain competency of the firm that guarantees performance.

The findings of sufficiency analysis on the combined dataset were largely replicated in the case of India and Korea but were somewhat different in the case of Brazil. This may possibly be because of the relatively small sample sizes and the significant differences in the industrial profile of the respondents of each country. The study's findings bring out the multi-dimensional nature of supply chain and the utility of using a composite variable, SCC, to measure its overall competency. More than any single factor, it is

the combined effect of all the factors that result in improved performance. The implications for managers are clear - they need to strengthen all the factors to achieve operational excellence. Supply chain performance is guaranteed for organizations which achieve overall supply chain competency. The study has some limitations. A sample size of 187 was used in the study. Future researchers may add to the validity of the findings by using a larger sample size and covering more countries. Further, respondents in the study were limited to manufacturers. Including suppliers and other supply chain members in a study will strengthen the findings. It may also reveal differences, if any, based on the role the organization in the supply chain.

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