Design of Supplier Development Programs for Indian Manufacturing Companies - A Supply Chain Perspective

THESIS

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CERTIFICATE

This is to certify that the thesis entitled **Design of Supplier Development Programs for Indian Manufacturing Companies - A Supply Chain Perspective** which is submitted for the award of PhD degree of the Institute, embodies original work done by C V Sunil Kumar, ID No 2011PH42115P, under my supervision.

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ABSTRACT

In the current competitive manufacturing business environments, the key suppliers along a supply chain have become the potential modes for the manufacturers to generate the sustainable competitive advantages. Consequently, the suppliers' capabilities and the manufacturer-supplier relationships are actively pursued and developed by the manufacturers in transforming their supply chains. As the suppliers have earned strategic roles to play in the value addition process, most of the manufacturers are inclined to have dependable suppliers and even propose certain supplier development initiatives so as to strengthen their supply bases. The Supplier Development Programs (SDPs) in this regard have been effective in nurturing the suppliers' contributions along the supply chains and establish strategic relationships with the suppliers. Although SDPs have the potential to efficaciously influence the manufacturer-supplier business conducts, there are no effective systems available to organize the implementation of SDPs and to sustain the results from the SDPs. Due to this, most of the manufacturers are becoming skeptical about the investments made in the SDPs and as a result the essential supply chain development that has to occur is greatly hampered. Thus, the current piece of research is focused on developing the systematic methodologies for a manufacturer's assistance in conducting the SDPs. Specifically, the manufacturers are provided with the approaches to efficaciously conduct the SDPs, address the impediments to SDPs and analyze the performances of SDPs. The methods to derive the right strategies for practicing the preferred supplier and preferred customer concepts are proposed and tested in the practical case situations of Indian manufacturing environment. Finally, the generic structural frameworks for achieving furtherance in the SDPs, for subduing the impediments to SDPs and for cultivating a manufacturer's preferred supplier and preferred customer relationships are developed in the interest of Indian manufacturing companies.

CONTENTS

List of Abbreviations

Average Direct Relationship Matrix	ADRM
Analytic Hierarchy Process	AHP
Analysis of Moment Structures	AMOS
Average Performance Ratings	APRs
Average Variance Explained	AVE
Buyer-Supplier Collaboration	BCL
Buyer-Supplier Communication	BCM
Buyer-Supplier Coordination	BCO
Buyer-Supplier Compliance	BCP
Binary Direct Relationship Matrix	BDRM
Business Expectancy from the Manufacturer	BEM
Bayesian Networks	BNs
Business Process Reengineering	BPR
Brand Value	BRV
Buyer-Supplier Cooperation	BSC
Buyer-Supplier Collaborative Efforts	BSCE
Buyer-Supplier Performance management	BSP
Buyer-Supplier Compatibility	BST
Buyer-Supplier Understanding	BSUD
Certifications, listings and Accreditations	CAC
Changing Customer Expectations	CCE
Contract's design with Conflict Management	CCM
Confirmatory Factor Analysis	CFA
Converting the Fuzzy data into Crisp Scores	CFCS
Comparative Fit Index	CFI
Cross Functional Teams	CFTs
Consistency Index	CI
Common Interests Component	CIC
Confederation of Indian Industries	CII
Competitive Position in the Market	CPM
Consistency Ratio	CR
Composite Reliabilities	CRs
Corporate Social Responsibility	CSR
Cost Savings and Value addition achieved	CSV
Directed Acyclic Graph	DAG
Defuzzified Direct Relationship Matrix	DDRM
Decision Making Trial and valuation Laboratory	DEMATEL
degree of freedom	df
Degree Of Possibilities	DOPs

Excellent	E
Employee Attrition Rate	EAR
Employees' Commitment in SD	ECI
Environmental Disasters	EDI
Exploratory Factor Analysis	EFA
Effective Focus on Core Competencies	EFC
Economy Fluctuations	EFL
Ethical and Moral Business Values	EMB
Efficient Product life cycle management	EPM
Enterprise Resource Planning	ERP
Efficiency in the Supply Chain Flows to the supplier	ESCF
Enhancement of Supplier Flexibility	ESF
Fair	F
Fuzzy Analytic Hierarchy Process	FAHP
Fuzzified Direct Relationship Matrix	FDRM
Financial Capability	FIC
Fuzzy-Matrice d'Impacts Croisés-Multiplication Appliquée à un Classement	FMICMAC
Fuzzy Performance Measure	FPM
Fuzzy Pair Wise Comparison Matrix	FPWCM
Final Reachability Matrix	FRM
Fuzzy Synthetic Extents	FSEs
Fuzzy Direct Relationship Matrix	FuDRM
Good	G
Goodness of Fit Index	GFI
Gujarat Industrial Development Corporation	GIDC
Group of Industry Experts	GIEs
Global Presence	GLP
Growth in the Market Share	GMS
Government's changing Rules and Regulations	GRR
Graph Theoretic Approach	GTA
Improved Availability of Products	IAP
Increased Access to World class capabilities	IAW
India Brand Equity Foundation	IBEF
Improved conditions of Backward Integration	IBI
Increased Business from the Manufacturer	IBM
Increased Collaborative Efforts from the manufacturer	ICE
Improved Change Management	ICM
Improved Customer status of the Manufacturer	ICMf
Improved Consistency in the Orders	ICO
Improved Corporate Reputation	ICR
Increased Customer Satisfaction	ICS

Improved Green Capability	IGC
Improved Knowledge base Development	IKD
Incapability at Manufacturer End	IME
Increased Competition	INC
Industry disruptions	IND
Innovation support Received	INR
Improved service to Preferred Customer	IPC
Improved treatment of Preferred Suppliers	IPS
Improved Responsibility on the Inputs	IRI
Improved Relationship Length	IRL
Impact Relationship Map	IRM
Initial Reachability Matrix	IRMt
Improved SC Responsiveness	IRP
Improved Relationship Strength	IRS
Improved Supplier Confidence	ISC
Improved SC Competence	ISCt
Improved buyer-supplier Skill Development	ISD
Inappropriate SD initiatives	ISDi
Improved SC Efficiency	ISE
Interpretive Structural Modeling	ISM
Involvement of SD in Supply Management activities	ISMa
Improved Supply Management	ISMg
Increased Supplier Reliability	ISR
Improved Supplier Selection	ISS
Ill effect of Suppliers' Supply and Demand	ISSD
Incorrect Selection of Supplier for development	ISSdp
Incorrect Supplier Selection and SD initiatives	ISSI
Improved Technological and Operational abilities	ITO
Insensitive and Unreliable Management Systems	IUMS
Information Visibility and Transparency	IVT
Improved Waste Management	IWM
Knowledge and Business Skills Development	KBD
Kaiser-Meyer-Olkin	KMO
Level of Aggregation achieved	LAA
Lack of Adaptability	LAT
Lack of Business Expectancy	LBE
Lack of Coordination	LCD
Lack of Compatibility	LCT
Lack of Competent Workforce	LCW
Lack of Manufacturer's Affirmation to the Supplier	LMAS
Lack of Mutual Trust	LMT

Longer Outstanding Payables	LOP
Large Potential Customer base	LPC
Low Preferred Manufacturer	LPM
Less Returns on Investments	LRI
Less strategic importance to purchasing	LSI
Lack of Top management Commitment	LTC
Lower Triangular Matrix	LTM
Lack of Total cost Perspective	LTP
Manufacturer's Attractive Business Conduct	MABC
Motivational Aspects Experienced by the Supplier	MAES
Manufacturer’s Characteristics Component	MCC
Mutual visits by Competent Personnel	MCP
Manufacturer’s Efficient and Effective Program	MEEP
Mismatch in Goals and Objectives	MGO
Manufacturer’s Interest Component	MIC
Mimetic Motive	MIM
Manufacturer’s pull on Inventory from Supplier	MIS
Manufacturer's Ineffective Systems of Operation	MISO
Manufacturer’s Project Completion exercise	MPC
Manufacturer's Poor Supplier Staking	MPSS
Manufacturer's Response in SD	MRSD
Manufacturer’s Stability, Capability and Development	MSCD
Manufacturer-supplier Collective Engagement	MSCE
Manufacturing Supply Chains	MSCs
Mutual site Visits by both supplier and manufacturer personnel	MUV
Normalized Average Performance Ratings	NAPRs
Nascent Relationship	NAR
Nimble Business Transactions	NBT
Normalized FSEs	NFSEs
Normative Motive	NOM
Normalized Weight	NW
Normalized Weight of Supplier Development Impediment	NWSDI
Original Equipment Manufacturers	OEMs
Outcomes in the Interest of a Both manufacturer and supplier	OIB
Outcomes in the Interest of a Manufacturer	OIM
Outcomes in the Interest of a Supplier	OIS
Oppressed and Limited Work Force	OLWF
Ordered Quantity and Frequency	OQF
Opportunistic behavior Supplier and Manufacturer	OSM
Order Winning Capability	OWC
Poor	P

Power and other Basic Supplies	PBS
Poor Buyer-Supplier Alignment	PBSA
Principal Component Analysis	PCA
Preferred Customer Components	PCCs
Preferred Customer Enablers	PCEs
Project Completion Exercise	PCEx
Poor Communication and Feedback systems	PCF
Poor Conflict Management	PCM
Poorly Connected Manufacturing Systems	PCMS
Poor connectivity between supplier and manufacturer	PCO
Preferred Customer Perception	PCP
Preferred Customer Status	PCS
Preferred Customers	PCs
Poor Devolution of Authority	PDA
Poor supplier Evaluation and Feedback systems related to SD	PEF
Manufacturer's Pressure on suppliers to follow Certifications	PFC
Performance Grading Level	PGL
Poor Information Exchange	PIE
Proximity to Manufacturing Base	PMB
Prompt Payments of Outstanding bills	PPO
Product and Packaging Quality	PPQ
Poor Profit and Risk sharing mechanisms	PPR
Post Purchase Service	PPS
Political Pressures and Uncertainties	PPU
Poor Resource Capabilities	PRC
Professionalization Motive	PRMt
Profit and Risk sharing Mechanism	PRM
Performance Ratings	PRs
Profit and Risk Sharing mechanism	PRS
Preferred Supplier	PS
Preferred Supplier Enablers	PSEs
Poor Support Extended to the supplier	PSEx
Poor Supplier capacity and Flexibility	PSF
Poor Supplier Integration	PSIt
Poor Supplier Motivation mechanisms	PSM
Preferred Supplier Status	PSS
Poor Technology and Knowledge transfer	PTK
Poor Turnout Time	PTT
Poor Volume and Valued business	PVV
Pair Wise Comparison Matrices	PWCMs
Reduced Buyer supplier Risks	RBR

Rapid Changes in Technology	RCT
Reduction in Inventory levels	REI
Random Index	RI
Returns on Innovation offered by the Manufacturer	RIM
Returns on Innovation	RIN
Root Mean square Residual	RMR
Root Mean Square Error of Approximation	RMSEA
Risk Prone Manufacturing Systems	RPMS
Reduced emphasis on Price Reduction	RPR
Reduced Supplier Complaints	RSC
Resource Sharing Mechanism	RSM
Supplier’s Adherence to Conventional practices	SAC
Supplier Awards and Recognition	SAR
Supplier's Business History	SBH
Supplier Characteristic Component	SCC
Supply Chain Management	SCM
Supplier's Compliance to Manufacturer’s initiatives	SCMi
Supplier’s Compatible Manufacturing Systems	SCMS
Supplier's Customer Satisfaction	SCS
Supply Chains	SCs
Supplier’s Conduct and Status	SCST
Supplier Commitment	SCT
Supplier Development	SD
Suppliers’ Disengagement and Dissatisfaction	SDDI
SD Impediments	SDIs
Supplier Development Outcomes	SDOs
SDP Performance Index	SDPPI
SD Practice and Reach	SDPR
Supplier Development Programs	SDPs
Supplier’s Expectations Component	SEC
Supplier's Environmental conscious Manufacturing	SEM
Supplier's Financial Capability	SFC
Supplier's Facility Distribution	SFD
Supplier Flexibility	SFL
Supplier Integration Achieved	SIA
Supplier's Innovation Capability	SIC
Supplier's Inability to adopt Changes	SICn
Supplier's Information Infrastructure	SII
Supplier Loyalty	SLY
Supply Management	SM
Scientific Management of SD	SMG

Supplier Motivation Strategies	SMST
Supplier's Organizational Culture	SOC
Strength of Leadership	SOL
Stability in Ordered Quantity	SOQ
Supplier Project Completion capability	SPC
Supplier's Physical Distribution system	SPD
Supplier Performance Level	SPL
Supplier's Potential for Manufacturer's Furtherance	SPMF
Supplier Proximity	SPR
Supplier Pricing Structure	SPS
Supplier's Preferential Support to a Manufacturer	SPSM
Statistical Package for the Social Sciences	SPSS
Supplier Reputation and Brand name	SRB
Supplier's Resource Capability	SRC
Supplier's Reluctance and Complacence	SRCp
Supplier Responsibility	SRE
Supplier Responsiveness	SREp
Suppliers' Resource Incompetency	SRIP
Supplier's Reluctance to Manufacturer's Initiatives	SRMI
Supplier's Response to Manufacturer's Requirements	SRMR
Supplier Responsiveness	SRP
Supplier Relationship Strength	SRS
Supplier Reliability	SRY
Supplier Strategic Alignment with the Manufacturer	SSAM
Supplier's Supplier Condition	SSC
Supplier Selection for Development from manufacturer	SSD
Structural Self-Interaction Matrix	SSIM
Supplier Fraud	SUF
Supplier Rewards/ incentives	SUR
Targets set to suppliers Along various Dimensions	TAD
Technological Capability	TEC
Triangular Fuzzy Numbers	TFNs
Total Interpretive Structural Modeling	TISM
Technology and Knowledge Transfer	TKT
Top Management Commitment	TMC
Targets achieved towards Mission and Vision	TMV
Total Relation Matrix	TRM
Trust	TRU
Increased Competition and Scarcity in Resources	UCSR
Unclear or Complex Targets set	UCT
Unscrupulous Internal and External Agents	UIEA

Unavailability of Natural Resources	UNR
Unethical practices by competitors	UPC
Underdeveloped region of operation	URO
Uncoordinated Systems of Resource Sharing	USRS
Unusual and Unstable Regions of Operation	UURO
Unpredictable and Uncertain Supply Chains	UUSC
Very Good	VG
Very Poor	VP
Worst	W
Weighted Average Performance Ratings	WAPRs
Work Culture	WCL
Weighted Fuzzy Performance Measure	WFPM
Weight of Supplier Development Impediment	WSDI
Weight of Supplier Development Impediment Category	WSDIC

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Chapter 1
Thesis Overview

1. Backdrop of supplier development

The concept of Supply Chain Management (SCM) became more prominent and prevalent among the companies during early 1980s. From then, the manufacturing business environments are enshrouded with numerous radical changes and have made the current SCM to become more complex. The major revolutionary transformation waves that have greatly influenced the SCM are globalization, compressed product life cycles, higher level of outsourcing, changed role and bargaining powers of the stakeholders, increased scarcity of resources, tremendous cost pressures, uncertain economies, rapidly progressing technology and ever increasing demands of the customers. Thus, it can be understood that the Supply Chains (SCs) have become more insistent and complex than ever before despite the tremendous advancement achieved.

The rippling effects of the abovementioned transformation waves are spread along the supply chains making the inputs from the suppliers also to become very important, critical, complex and strategic in nature for the manufacturers. Indeed the purchasing portion of the supply chains has been greatly revived and is now capable of offering sustainable ways for generating the cost saving as well as profit making opportunities (Anderson and Katz, 1998). From the cost perspective, the purchasing function at times account for 60 - 80% of the total costs (Anderson and Katz, 1998; Trent and Monczka, 1998; Van Weele, 2009; and Monczka et al., 2015). Moreover, with regards to the cost savings, Anderson and Katz (1998) mentioned that the cost reduction through the purchasing function is less painful than by downsizing the staff. Chopra and Meindl (2007) also stated that the profit made through cost reduction in the purchasing is far greater than the profit made through the increased sales. However, the manufacturers cannot afford to pressurize the suppliers to reduce their profit margins for achieving cost reduction (Wu et al., 2011). This has indeed led to the serious threats posed on to the entire manufacturing supply chains, at times even costing the focal manufacturer's hard earned reputation. Nonetheless, by favorably focusing on the profit making opportunities with the suppliers and by proposing win-win strategies, the manufacturers can gain numerous sustainable competitive advantages (Anderson and Katz, 1998). This sort of functioning with the suppliers has become essential and inevitable, as the stakeholders' contributions in the value addition process have become very significant to stay ahead of the competitors. As a result, now the competition is no longer among the individual manufacturing businesses, but has been extended to the manufacturing supply chains as a whole (Lambert and Cooper, 2000). Further, it said that the success of a manufacturing company along the supply chain competition is often determined by the strength of the SC in which it is operating and is determined by the SC's weakest link (Fawcett et al., 2012). So, in practice the SC managers are urged to identify the weakest link along the SCs and direct their efforts in strengthening it for overall SC development. Thus, the competition among the SCs will revolve around SC development in future i.e. strengthening of the SC network along upstream, downstream and along the lateral stakeholders who are responsible for producing the goods, services or other value adding functions (Moser, 2007; and Melewar et al., 2013). From a range of unexplored potential opportunities to the threatening scandals (like horse meat scandal experienced in UK), the Supply Management (SM) is often treated as a weakest link in the SCs that has to be strengthened. Even the suppliers' role along the manufacturing SCs has been greatly elevated from last two decades viz. with regards to early supplier involvement in the new product development and generating the supplier innovation (Parker et al., 2008; and Lee and Kim, 2011). This is also evident from the strategic roles awarded to the suppliers, changes in the functional approach of the purchasing to strategic SM, transformations in the transactional buyer-supplier relationships to collaborative, cooperative and coordinative, increased outsourcing to the suppliers while the manufacturers tending to focus on core competencies and the competition for preferred relationships with the suppliers (Joo et al., 2009; Loppacher et al., 2011; Mishra et al., 2013; and Sucky and Durst, 2013). Owing to the strategic importance ascribed to the suppliers, the Supplier Development (SD) strategy has been actively adopted by many manufacturing companies to make their critical suppliers capable in order to make their SCs competitive.

It was Leenders (1965) who first mentioned the term "Supplier Development" (SD). The SD has been defined and studied by various researchers, academicians and practitioners in different situations (Leenders, 1965; Hahn et al., 1990; Krause and Ellram, 1997; Krause, 1999; Handfield et al., 2000; Wagner, 2006; Modi and Mabert, 2007; Brashear Alejandro et al., 2013; and Nagati and Rebolledo, 2013) with a central focus to enhance the capability of a supplier and with an aim to create win-win situations between a manufacturer and its suppliers. Krause and Scannell (2002) defined the term SD as, "Any effort of a buying firm to increase the performance of a supplier". It has been proven that certainly an SD improves the performance of the suppliers along the multi-dimensions like quality enhancement; delivery improvement; cost reduction; flexibility; sustainability; knowledge transfer; enhancement in the technological and product design capabilities; and in providing the better and reliable services (Monczka and Trent, 1991; Morgan, 1993; Hartley and Jones, 1997; Reed and Walsh, 2002; Giannakis, 2008; Talluri et al., 2010; Wagner, 2010; and Shokri et al., 2010). In addition to the basic performance dimensions, manufacturers also expect for certain elusive aspects such as relationship strength, integration, cooperation, coordination, collaboration, innovation transfer, commitment, trust, preferential status, compliance, and involvement. In general, manufacturers expect the suppliers to dynamically fulfill these dimensions in varying degree and in different combinations for contesting better than the competitors in fulfilling their customers' requirements. (Smith, 2010; Li et al., 2012; Yazici, 2012; Praxmarer-Carus et al., 2013; Blonska et al., 2013; New, 2013; Egels-Zandén, 2014; and Yan and Dooley, 2014). So, the manufacturers are moving from transaction and arms-length based relationships to strategic supplier relationships with an aim to bind the right supplier at right time in a right way in order to competitively meet these expectations. Previously, the companies were many a time vertically integrated, but now to gain the best across the SCs, manufacturers are inclined to depend more on the capable suppliers (Kaipia and Tanskanen, 2003). This transformation has led the manufacturers to greatly increase the percentage outsourcing so as to take the advantage of suppliers' expertise. Henceforth, the manufacturers will have to consciously integrate, evaluate and improve the activities across its partners and strengthen the overall supply chain better than the competitors (Joo et al., 2009; and Humphreys et al., 2011). In this regard, although the Supplier Development Programs (SDPs) can potentially offer fruitful results, but in research and practice there are some gross to subtle aspects that are overlooked in conducting the SDPs. This is because the SC dynamics are dictated by many factors such as the environment of operation, resources available, field constraints and other tangible and intangible issues. So, the parameters on which the SCs operate would dynamically vary and hard to manage, predict and even prevent. This is true for the SDPs as well and hence, there cannot be a single devised solution for all the problems. Foreseeing this, very few studies are available to address the ground realities and enable the practice of SDPs irrespective of the dynamic challenges thrown at the supply chain managers. In the current thesis, the prominent aspects that can nurture the efficacy of the SDPs are exclusively examined and are briefly discussed in the following sections.

1.1 Research gaps focused in the current thesis

In this section, the identified research gaps, their significance and the proposed solutions are briefly discussed. The literature support for the derived research gaps is contextually presented along the different chapters in the current thesis so as to comprehensively develop the discussion.

1.1.1 Strategic analysis of supplier development programs

A manufacturer has to lay out strategic emphasis in conducting the SDPs and proactively make use of its suppliers' capabilities and contributions in the value addition process. In practice, most of the SDPs are not conducted strategically but often the SD initiatives proposed are reactive in nature. Due to this, the manufacturers and suppliers are seriously lacking the essential consensus in the planning and execution of the SDPs. Although SDPs are aimed for better returns on investments, majority of the companies come to nothing being overwhelmed by the plan of action, management, improvement and transformation in the SDP implementation. Indeed, the successful implementation of SDPs is a great challenge for many manufacturing companies due to numerous reasons. These reasons include but not confined to ignorance about an SDP implementation, no complete knowledge about what an SDP can offer, no serious and sincere aspirations to implement the SDPs (may it be due to manufacturer's fear about suppliers' loyalty; resistance to invest in the SDPs; lack of knowledge, skill, and experience to devise the proper SD initiatives; suppliers' negligence; and suppliers' resistance to take part in the SDPs). and lengthier SCs (Manuj et al., 2013; Ho and Ganesan, 2013; and Patil and Kant, 2014). The causes of these reasons dynamically vary and defy the SC managers to decide on what strategy to adopt for successfully implementing the SDPs. In this regard, a methodology is proposed to quantify the success factors and accordingly suggest the action plans for the manufacturers.

Apart from the successful implementation, on the other hand, many companies even though capable of conceiving and materializing their SD strategies, are miserably falling short off due to the tremendous misdirected flow of resources. Often, due to the misdirected SD efforts and the bitter experiences as a consequence, the companies are pushed to draw wrong conclusions and inevitably search for other misdirected efforts without addressing the root cause impediments. In concrete, the misdirection in an SD has its deep roots along various tangible and intangible issues of the operation field which requires a consensual approach. But, often there exist complex relationships between these impediments leaving a manufacturer clueless about which one to focus. So the standard approaches to overcome the SD Impediments (SDIs) in general do not help the manufacturing firms. This is often why many manufacturing firms complain or conclude that the SD is not the right strategy they should have chosen. In fact, many manufacturing firms quickly come to this conclusion that nothing can materialize in their firm and develop strong resistance for the transformation. But any kind of strategy turnout unsuitable unless right impediments are identified and the root causes among them are addressed. However, many at times manufacturing companies fail to identify the right ones to focus due to the complex and chaotic relationships amidst them. Thus a methodology has been proposed for a manufacturer's assistance to address the prominent impediments to the SDPs in the current research work.

Having analyzed the success factors and the prominent impediments to the SDPs, it is also essential for a manufacturer to measure the performances of its SDPs. In this regard, a manufacturer must have an approach to periodically measure the performances of its SDPs and have a basis to focus on the right Supplier Development Outcomes (SDOs) in improving the SDPs. The said performance analysis must help a manufacturer to know more about the functioning of its SDPs so as to efficiently direct its investments and efforts on the right SDPs. Both in research and practice there is no such specific emphasis available to measure, monitor and manage the performances of SDPs. So a methodology has been proposed in this study for measuring the performances of SDPs.

1.1.2 Preferred customer concept

Earlier, the manufacturers were not much affected even though the good suppliers were limited to mere functional role and the relationships maintained with them were of arm's length in nature. But, due to the recent revolutionary changes in the business environments, the manufacturers can no longer afford to disregard their suppliers and act in silos. Hence, now-a-days, it is seen that the manufacturers' dependency on the suppliers has been increased enormously, so much so the good suppliers' perception in dealing with their manufacturers is given importance. As the demand for specialized suppliers has been increasing more than ever, suppliers' discernment for Preferred Customers (PCs) opens up new gateways for progressive supply chains. Previously, since the suppliers were not privileged to have their discernment about the manufacturers, their perspectives were not much explored in the literature and subsequently not many approaches are available for cultivating the preferred customer relationships. But, now-a-days the suppliers are often having multiple manufacturing-customers making a particular manufacturer one among several manufacturers competing for the same type of products/services. This makes a supplier implicitly biased in extending and offering its best to few preferred customers, making it difficult for the manufacturer. Hence, it is always a test for a manufacturer to manage and distinguish itself as a preferred customer specifically from its key suppliers' perspective. Although the concept of preferred customer can bring about a tremendous change in the business practices, it has been an ignored topic both in research and practice. It is in this regard, the preferred customer enablers that position a manufacturer as a preferred customer were analyzed. Then a process for measuring Preferred Customer Status (PCS) has been proposed and tested in a practical case situation.

1.1.3 Preferred supplier concept

Suppliers' role has been gaining strategic significance among the manufacturing supply chains as the competition between them is potentially guided by the strength of their supply base and the level of supply chain integration achieved. Most of the manufacturers started realizing that the tradition of treating their suppliers functionally put them on the losing end rather than gaining and so, the manufacturers have started exploring and at times developing their supply bases to gain competitive advantages. In this regard, the Preferred Supplier (PS) concept is pursued by the manufacturers so as to have long term relationships established with few dependable suppliers. Hence, usually the manufacturers are looking for closer and favored relationships by bringing in the concept of preferred supplier while dealing with their key suppliers. This emphasis on preferential relationships has been providing a manufacturer an extra cutting-edge in tackling the increased competitive pressures and reduced availability of resources. Although, the preferred supplier concept can fetch enormous welfare to a manufacturer's business, nonetheless most of the manufacturers do not have proper basis in implementing the concept.

1.1.4 Empirical studies

The SDPs must not only strengthen the immediate suppliers of the focal manufacturers along the supply chains but also the suppliers in the upstream of supply chains. It is with this motive an empirical study was conducted to establish an SD furtherance model for a systematic execution and extension of an SD into the backward linkages of the manufacturing supply chains in India. Further, a pragmatic survey is also conducted to explore the interactions among the impediments to SDPs. The study has comprehensively incorporated the prominent impediments that originate from different sides (i.e. supplier, manufacturer, manufacturer-supplier and external environment) and provided a basis for a manufacturer to effectively conduct the SDPs. Also the essential and necessary aspects that the manufacturers have to focus in cultivating the preferred supplier relationships are examined in the current study. A structural framework is developed that can efficaciously assist a manufacturer in developing the preferred supplier relationships. Further, a process is proposed to determine the extents in cultivating the preferred supplier relationships on the basis of the developed structural framework. Finally, the essential and necessary aspects that position a manufacturer as a preferred manufacturing customer are empirically examined. From the empirical analysis a structural framework was developed and a process was suggested through which a manufacturer can determine the extents in cultivating the preferred customer relationships.

1.2 Thesis outline

In the first chapter, the backdrop of Supplier Development (SD) along with the significance of current research focus are introduced. As shown in the Figure 1.2.1, the strategic analysis of SDPs has been focused in the second chapter. Further in the second chapter, the approaches for successful implementation of SDPs, addressing the impediments to SDPs and performance analysis of SDPs are explained along with the results from the practical case situations. Then, the preferred customer concept which is the most ignored topic in research and practice in relation to SD has been studied in the chapter 3. Specifically, a study has been conducted for deriving a strategy in cultivating the preferred customer relationships in an Indian manufacturing environment. Moreover, a process for measuring the preferred customer status of a manufacturer has been proposed and tested in a practical case situation. Further in the chapter 4, the preferred supplier concept has been studied. Similar to the preferred customer concept, a study has been conducted for deriving a strategy in cultivating the preferred supplier relationships. The process for measuring preferred supplier status also has been proposed and tested in a practical case situation. In chapter 5, an SD furtherance model for systematic SD execution and extension into the manufacturing supply chain backward linkages in an Indian manufacturing environment is established. Further, the combined effects of the structural variables are studied by analyzing the results obtained from the diagnosis of the SD furtherance model structured as a Bayesian network. In chapter 6, the interactions among the impediments to SDPs are studied through a pragmatic survey conducted in an Indian manufacturing industry.

The study has comprehensively incorporated the prominent impediments originate from different sides (i.e. supplier, manufacturer, manufacturer-supplier and external environment) and provided a basis for a manufacturer to effectively conduct the SDPs. In chapter 7, the directed relationships among the principal components extracted by analyzing the essential aspects in cultivating preferred supplier relationships are analyzed and a generic structural framework is developed. The structural framework is then utilized in the application of graph theoretic approach which provides a manufacturer to assess the extent to which the preferred supplier relationships can be developed. In chapter 8, the directed relationships among the principal components extracted by analyzing the essential aspects in cultivating the preferred customer relationships are analyzed and a generic structural framework is developed. The structural framework is then utilized in the application of graph theoretic approach which provides a manufacturer to assess the extent to which it can achieve preferred customer relationships with the suppliers. Finally, the results obtained from the studies are concluded along with the possible future research directions.

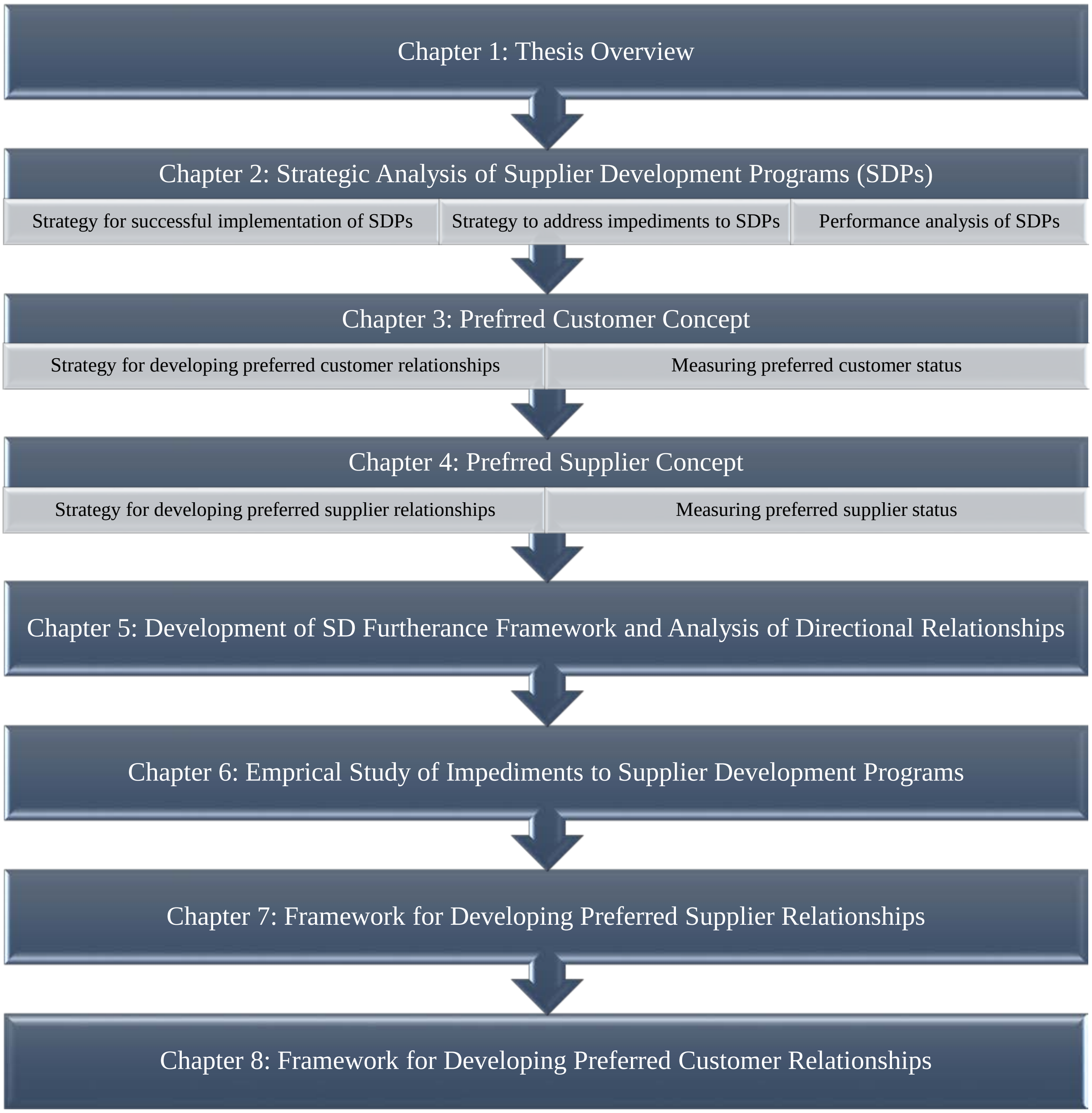


Figure 1.2.1 Thesis outline showing the flow of research work

Chapter 2

Strategic Analysis of Supplier Development Programs

2. Sectional outline

This section presents the processes for conducting strategic analysis of the SDPs and are presented along the three sub-sections. Section 2.1 deals with the process for deriving a strategy for successfully implementing the SDPs. Section 2.2 demonstrates the proposed methodology for analyzing the SDIs. Section 2.3 confers about the performance analysis of the SDPs.

2.1 Sectional abstract for deriving a strategy for successful implementation of SDPs

The purpose of this section is to present an approach for identifying, evaluating, quantifying, prioritizing and establishing the relationships (i.e. cause and effect) among various Supplier Development Program Enablers (SDPEs) in a specific manufacturing environment. The proposed approach runs through four phases i.e. defining Supplier Development Program (SDP) environment, identifying the relevant SDPEs, capturing the experts' qualitative opinions for the SDPEs and analyzing the SDPEs using Fuzzy DEMATEL. The fourth phase of the proposed methodology is programmed using Matlab 7.10.0 (R2010a). The developed Matlab program can quickly and reliably transform the experts' opinions and publish the results that are easy to analyze and interpret. It was deployed in an Indian manufacturing company and the results were analyzed to provide directions for the company while implementing the SDPs. The major findings that the case company could obtain from the proposed methodology were, the rankings of the SDPEs, classification of the SDPEs into cause and effect groups, and interactions established among the SDPEs using an impact relationship map. Out of twenty SDPEs considered in the analysis, "Top Management Commitment" and "Mutual Visits by competent personnel from both sides" were the two most important SDPEs for implementing the SDPs in the Indian case company (in which a case study was conducted). The outcomes from the methodology were verified by consulting the said company's experts and their validity was confirmed. However, since the results obtained were specific to a manufacturing environment, they cannot be generalized. But, the proposed approach can be adopted for analyzing the SDPEs in any manufacturing environment, once the set of SDPEs corresponding to that environment are selected considering the specific priority considerations. To highlight the originality of the work, the proposed methodology has the capability to rank the SDPEs and their interrelationships. This will greatly help the supply chain managers to precisely choose and manipulate the SDPEs for successful implementation of the SDPs.

2.1.1 Introduction to the process of deriving a strategy for a successful SDP

The manufacturing supply chains have become far increasingly complex despite the tremendous progress in different areas like technology, business strategies, scientific practices, and business analytics. As discussed earlier, the complexities that the manufacturing supply chains have to deal with have been increased far beyond the advancement made across various areas. These complexities in turn lead to various uncertainties across the manufacturing supply chain and out of these uncertainties, the uncertainty related to supply is the significant one in many situations. The supply uncertainty poses negative effect on the performance of an entire manufacturing supply chain due to lack of manufacturers' control over its supply base and their integration. Therefore, even though a manufacturer is able to achieve excellence in its operations, still it has to ensure that its suppliers are also capable enough to operate at its expected level or beyond which in turn gives it the competitive advantages. Many times, the manufacturer adopts SDPs to bring down the supply uncertainty and to reduce the supplier performance gaps (i.e. difference between the expected and actual supplier performance) (Monczka et al., 1993). It is understood that the SDP is an initiative taken by a manufacturer to make its suppliers competent, but this is not the only alternative available. The other alternatives are to bring the outsourced item in-house and produce it internally or switch over to a more capable supplier (Krause et al., 1998). The choice among these alternatives is often decided on the basis of price, volume or the strategic nature of the procured item (Handfield et al., 2000). Supplier switching is preferred for low-value and non-strategic commodities (one extreme) and the manufacturer may acquire the supplier if an underperforming supplier is providing an innovative product or process technology (other extreme). But, if the situation lies in between these two extremes, then the best alternative to opt is "Supplier Development" (Handfield et al., 2000). In the current study, an attempt is made to identify, quantify and study the interactions of SDPEs in the manufacturing supply chain environment. The SDPEs are those which help the companies to practically implement and successfully tap the benefits from an SDP. Nonetheless, the SDPEs have to be clearly understood for monitoring, controlling and improving the performance of SDPs. It requires constant identification and quantification of SDPEs. Unless the identified SDPEs are quantified, little information will be available about the current and ideal stages at which an SDP has to be operated. Further, the quantification also helps in identifying the level of importance of each SDPE. But, the conditions for a successful SDP are specific for the specific suppliers. Therefore, an SD initiative calls for an analysis of the relevant supplier to match the development effort to its specific needs (Granman and Helgosson, 2013). Hence, the importance and relationship of SDPEs are not same for all types of SDPs, as it depends on the environmental conditions in which they are operating and other related constraints. A generic methodology is proposed using Fuzzy DEMATEL to identify the SDPEs, determine their strength, establish their relationship (i.e. cause and effect), and develop an impact-relationship map. The proposed methodology ass applied to an Indian manufacturing company in order to explain the salient features of the concept.

In this chapter, the section 2.1.2 presents the literature review conducted on SDPEs; section 2.1.3 deals with the proposed methodology for analyzing the SDPEs; section 2.1.4 features the analysis of SDPEs using the proposed methodology for an Indian manufacturing company;

section 2.1.5 includes the results and discussions; and section 2.1.6 highlights the inferences drawn from the interpretation of the results.

2.1.2 Literature review on SDPEs

The SDPEs are those which trigger the successful implementation of SDPs. They determine a system's behavior and are at the disposal of a manufacturer in order to monitor, stimulate and transform the SDPs. However, many manufacturers find it a challenge for analyzing the SDPEs, to focus on right SDPEs and achieve better returns on investments. The literatures published have not dealt these issues in great detail, but many researchers have explored and emphasized the significance of analyzing the enablers in dealing with different dimensions from SDPs. These include but not limited to, outcome based SDPs (in terms of quality, reliability, agility, flexibility, cost, delivery speed, and sustainability), SC flow based SDPs (in terms of resource sharing, profit and risk sharing, information sharing, innovation flow, relationship length, level of significance attached to different suppliers and the products or services they supply), criteria based SDPs (prioritizing the critical elements to exercise for a healthier SDP and SDPs' environment of operation and so on and so forth. In addressing these dimensions, many research studies have been conducted on SDPEs by focusing on various combinations like the studies conducted on SDPEs as a whole, studies conducted to analyze certain group of SDPEs in relation to the desired potential outcome(s) of a manufacturer and studies conducted for scrutinized examination of a particular SDPE alone. Also, SDPEs have studied according to the context, industry, region and benefactor's view. However, there are not enough literatures available which carried out extensive analysis of an SD by considering all the scenarios as well as intricacies of SDPEs. SDPEs are often labeled with different names by various researchers such as criteria, factors, drivers, elements and attributes which are nothing but input variables influencing different SDP output variables. The researchers' focus pertaining to the analysis of various SDPEs is shown in Table 2.1.1.

From the literature review, it can also be inferred that not many literatures are available for carrying out the complex studies on SDPEs specifically on how to identify, evaluate, quantify, prioritize and establish the relationships (i.e. cause and effect) among the SDPEs and facilitate decision making for an effective management of SDPs. This section is an attempt to enhance the process by addressing the loopholes in the system.

2.1.3 Proposed methodology for analysing the SDPEs

A methodology is proposed to analyze the SDPEs for successfully implementing SDP in a manufacturing environment. The following flowchart and the sections systematically present development of proposed methodology.

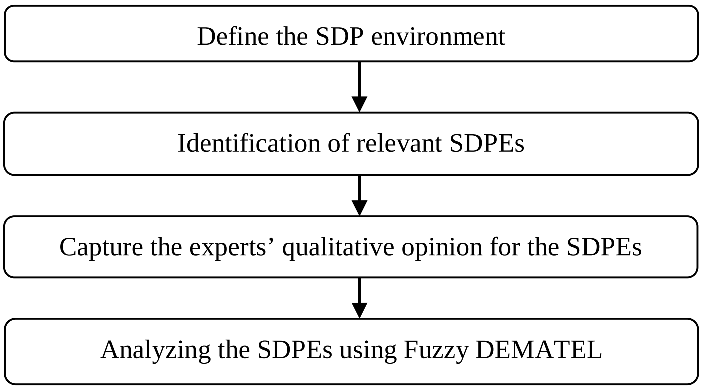
2.1.3.1 Definition of SDP environment

Due to SDP's dependency on the manufacturing environment, it is extremely important to identify the environment in which SDP is implemented. The environmental condition is defined but not restricted to supply chain strategy (i.e. agile, lean, le-agile), size (i.e. both manufacturer and supplier), nature of the product, region of operation, organizational culture and structure (i.e. both manufacturer and supplier), types of manufacturing environment (i.e. make to order, make to stock, assemble to order and engineer to order), and constraints (i.e. both manufacturer and supplier).

Table 2.1.1 Literature review on analysis of SDPEs

Author	Research focus
(Krause and Ellram, 1997a)	Identified factors contributing to SD success and provided insights into why buying firms' SD success varies.
(Krause and Ellram, 1997b)	Emphasized that effective two-way communication, top management involvement, teams, and purchasing a relatively large percentage of the supplier's output are critical to the supplier development effort. Identified critical elements of SD conducted survey on US buying firms to capture buying-firm's perspective.
(Krause, 1999)	Identified the important factors that influence a firm's involvement in supplier development and concluded that supplier commitment, expectation of relationship continuity and effective buyer–supplier communication are the antecedents.
(Wynstra and Ten Pierick, 2000)	Focused on supplier involvement and introduced supplier involvement portfolio approach to distinguish in to four types of supplier involvement in new product development projects.
(Prahinski and Benton, 2004)	Studied how suppliers perceive the buying firm's supplier evaluation communication process and its impact on suppliers' performance and concluded that it does not ensure improved supplier performance unless the supplier is committed to the buying firm. Buying firms can influence the supplier's commitment through increased efforts of cooperation and commitment.
(Reed and Walsh, 2002)	Stressed on the potential to enhance the technological capability of the supply network through SD schemes, presented case studies of SD in UK aerospace and defense sectors.
(Modi and Mabert, 2007)	Presented a conceptual model of an organization's efforts to improve supplier performance. They examined in specific how knowledge transfer improves supplier performance in SD, in US manufacturing firms.
(Chidambaranathan et al., 2009)	Developed a structural model of SD factors, studied SDPEs as a whole irrespective of the type of industry. Mentioned that many literatures did not consider the interactions between the factors with respect to SD. Explained that how interrelationship between factors aid in thorough understanding of the situations. Commented that statistical methodologies used, just test the significant difference among the SD factors which are based on probabilities (no full certainty) and they do not explain the reasons in differences.
(Carr et al., 2008)	Developed an integrated research model that investigates the relationships among the SDPEs specifically communication methods, information sharing within a firm, information sharing between firms, and support aimed at SD and the effects these relationships have on firm performance.
(Giannakis, 2008)	Focused on factors that condition learning and knowledge transfer through SDPs and developed a conceptual framework for analyzing knowledge transfer among and between organizations and a knowledge-based perspective in the design and management of SDPs.
(Govindan et al., 2010)	Presented an approach for identifying and ranking of SD criteria in their analysis for an automobile industry and developed a framework for SD.
(Bai and Sarkis, 2010)	Introduced a formal model to investigate the relationships between organizational attributes, SDP involvement attributes, and performance outcomes in the green context.
(Ghijsen et al., 2010)	Examined supplier satisfaction and commitment with respect to influence strategies and SD.
(Large and Thomsen, 2011)	Developed a model on the basis of potential drivers of green SD to explain environmental and purchasing performances in German industries.

Figure 2.1.1 Proposed methodology for analysing SDPEs



2.1.3.2 Identification of relevant SDPEs

The SDPEs are to be identified through literature review, brain storming sessions and discussions with industrial experts, researchers and academicians. In order to achieve accountancy and relevancy in the SDPEs, they have to be thoroughly in line according to the nature of defined SDP environment and priority considerations of the manufacturer (section 2.1.1). To determine the significant SDPEs and for effective and efficient management of SDPEs, further analysis has to be carried out. Hence, the identification and analysis of SDPEs are inevitable and are manufacturing environment dependent.

2.1.3.3 Capturing the experts' qualitative opinion for the SDPEs

The experts' qualitative opinions regarding mutual influence of the relevant SDPEs should be captured by using a pair wise comparison matrix. These pair wise comparisons should be carried out by using the linguistic variables i.e. no, low, medium, high and very high influence (see Table 2.1.2).

Table 2.1.2 Quantification and fuzzification scale for linguistic responses

Linguistic terms	Influence score	Triangular fuzzy numbers
No influence (No)	0	(0,0,0.25)
Very low influence (VL)	1	(0,0.25,0.50)
Low influence (L)	2	(0.25,0.50,0.75)
High influence (H)	3	(0.50,0.75,1.00)
Very high influence (VH)	4	(0.75,1.00,1.00)

2.1.3.4 Development of fuzzy DEMATEL for analyzing the SDPEs

The DEMATEL (Decision Making Trial and valuation Laboratory) method developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976 was used to research and solve complicated and intertwined problem groups (Fontela and Gabus, 1974). It has the capability to convert the relations between criteria/ SDPEs into a visual structural model (Hori and Shimizu, 1999; Wu and Lee, 2007; and Wu, 2008). It quantifies experts' qualitative opinions to build a systematic structure of a problem. But, experts' opinions concerning a complex problem like SDP is mostly vague. Therefore, Fuzzy DEMATEL is adopted for analyzing the SDPEs. The notations used in the Fuzzy DEMATEL algorithm are:

F:	Fuzzified Direct Relationship Matrix (*FDRM*)
$F_{ij} = (l_{ij}, m_{ij}, r_{ij})$:	Elemental value of *FDRM*, where it indicates the degree that a criterion i influences criterion j
$(xl_{ij}, xm_{ij}, xr_{ij})$:	Normalized value of (l_{ij}, m_{ij}, r_{ij})
$min\ l_{ij}$:	Column wise minimum l_{ij}
$max\ r_{ij}$:	Column wise maximum r_{ij}
xls_{ij}:	Left spread measure of normalized fuzzy number
xrs_{ij} :	Right spread measure of normalized fuzzy number
x_{ij}:	Total normalized crisp value calculated from left and right spread measures of normalized fuzzy numbers
z_{ij} :	Crisp value defuzzified from triangular fuzzy number

z^k: Defuzzified matrix obtained from the k^{th} expert

h: Number of experts

n: Number of criteria

$T=t_{ij}$: Total Relation Matrix (*TRM*)

$A=a_{ij}$: Average Direct Relationship Matrix (*ADRM*)

$\max\limits_{1\le i\le n}\sum\limits_{j=1}^{n} a_{ij}$: Total direct influence of the criteria on other criteria

$\max\limits_{1\le j\le n}\sum\limits_{i=1}^{n} a_{ij}$: Total direct influence received from other criteria

R: Vector of length $n$representing rows sum of the *TRM*

C: Vector of length $n$representing columns sum of the *TRM*

The step by step procedure of Fuzzy DEMATEL algorithm for analyzing the SDPEs is mentioned below:

Step 1 Quantification and fuzzification of linguistic responses

Pair wise comparison matrices developed through experts' qualitative opinions are in terms of linguistic responses (see section 2.1.3). Transform these response matrices using a scale 0-4 (see the influence scores field of Table 2.1.2) to get quantified direct relationship matrices. Subsequently, fuzzify the matrices to capture the uncertainty in the experts' opinions such that the results obtained are much more accurate. To develop fuzzified direct relationship matrices, convert the influence scores assigned to the linguistic variables into triangular fuzzy numbers as mentioned in Table 2.1.2.

Step 2 Development of defuzzified direct relationship matrix of each expert

Develop the Defuzzified Direct Relationship Matrix (*DDRM*) for each expert using CFCS (Converting the Fuzzy data into Crisp Scores) method (Opricovic and Tzeng, 2003). The details of CFCS are mentioned below:

(i) Normalization:

$$xr_{ij} = (r_{ij} - minl_{ij})/\Delta_{min}^{max}$$

$$xm_{ij} = (m_{ij} - minl_{ij})/\Delta_{min}^{max}$$

$$xl_{ij} = (l_{ij} - minl_{ij})/\Delta_{min}^{max}$$

(where, $\Delta_{min}^{max} = \, max\, r_{ij} - \, min\, l_{ij}$)

(ii) Left and right spread measures of normalized fuzzy numbers,

$$xrs_{ij} = xr_{ij}/(1 + xr_{ij} - xm_{ij})$$

$$xls_{ij} = xm_{ij}/(1 + xm_{ij} - xl_{ij})$$

(iii) Compute total normalized crisp score

$$x_{ij} = \left[xls_{ij}\left(1 - \, xls_{ij}\right) + xrs_{ij} \times \, xrs_{ij}\right] / \left(1 - \, xls_{ij} + xrs_{ij}\right)$$

(iv) Compute crisp value

$$z_{ij} = \, \min l_{ij} + \, xr_{ij} \, \times \, \Delta_{min}^{max}$$

Step 3: Development of Average Direct Relationship Matrix (ADRM)

Calculate the *ADRM* by taking the average of all 'h' *DDRMs* (where, h is the number of experts).

If $z^1, z^2, z^3, \dots, z^h$ are the DDRMs obtained then *ADRM* (A) is obtained as shown below,

$$A = (\sum_{k=1}^{h} z^k)/h$$

The *ADRM* elemental values can be represented as $A = [a_{ij}]_{n\times n}$

Step 4: Normalization of Average Direct Relationship Matrix

The normalized *ADRM* is denoted as *D*. It is calculated as follows

$$D = \frac{A}{S} \; where \quad S = \max\left(\max_{1\le i\le n} \sum_{j=1}^{n} a_{ij}, \max_{1\le j\le n} \sum_{i=1}^{n} a_{ij} \right)$$

Step 5: Computation of total relation matrix

$T = D(I - D)^{-1}$ where, I is the identity matrix.

$T = [t_{ij}]_{n \times n}$

Step 6: Prioritization (i.e. degree of importance) of SDPEs

Develop R and C vectors from the total relation matrix (T) obtained in the previous step. Where, R represents the row sum of matrix T:

$$R = \left[\sum_{i=1}^{n} t_{i1} \sum_{i=1}^{n} t_{i2} \dots \sum_{i=1}^{n} t_{ij} \dots \sum_{i=1}^{n} t_{in}\right]$$

(where, j represents the row number, i represents column number and n represents number of rows or columns of matrix T, since T is a square matrix).

Similarly, C represents column sum of matrix T:

$$C = \left[\sum_{j=1}^{n} t_{1j} \sum_{j=1}^{n} t_{2j} \dots \sum_{j=1}^{n} t_{ij} \dots \sum_{j=1}^{n} t_{in}\right]$$

From R and C vectors, determine the $R + C$ vector (where each element of the vector indicates the degree of importance of the corresponding enabler) and prioritize the enablers.

Step 7: Segregation of SDPEs into cause and effect groups

Determine the $R - C$ vector from R and C vectors obtained in the previous step. The positive signed elements indicate that the corresponding enablers are causes and the negative elements indicate effects.

Step 8: Development of causal diagram

Develop a causal diagram for the SDPEs taking their $R + C$ and $R - C$ values along X-axis and Y-axis respectively.

Step 9: Development of impact relationship map

On the basis of experts' opinion, set the threshold value for developing impact relationship map. This threshold value filters out insignificant interdependent relationships between SDPEs. It must be deducted from all the elements of *TRM* to obtain *significant TRM*. Eliminate negative elements from *significant TRM* to determine the *reduced TRM*. This *reduced TRM* forms the basis for developing the impact relationship map.

2.1.4 Analysing SDPEs using the proposed methodology – A case application

A leading Indian large scale automotive manufacturing company (denoted as Company 'A' from now on) was approached to validate the proposed methodology. The company's top management was excited with the proposed methodology and agreed to extend their cooperation by providing necessary inputs. In the first phase (see section 2.1.1), emphasis was laid on understanding the company A's SDP environment in order to define its nature. It has large customer base both in India and abroad with global brand value for its products. The supply chain strategy of the company is to supply high quality, customized and innovative products. It has suppliers based at local level (i.e. those located within the reach of 1000 KM) as well as further off (i.e. those located at a distance greater than 1000 KM). The company is selective in its suppliers considering many factors. It is noticed that the non-local suppliers chosen by the company are few and follow certain high standards with no or minimal issues to deal with. To minimize the total costs, the company 'A' mainly has large number of local suppliers; but all of them are not good enough in meeting its requirements. It has wide spectrum of customers with different set of requirements and policies. Hence, it has categorized its suppliers in serving as per the customer's potential and requirements. The company A's manufacturing environment is typical as it is in transition phase from its conventional to lean manufacturing. Because of its attempts to lower inventory levels, numerous problems aroused at supplier side in terms of delivery delays, poor quality and product and process design issues. To solve these, the company 'A' decided to adopt SDPs. It started separate SD department with the aim to make its suppliers competent. Some observations were made regarding SDPs running in the case company after thorough study of SDP implementation systems and detailed discussions held with SD department personnel. Although the company's image is improved through SDPs, yet it is not optimizing the benefits that SDP can offer. There are no potential competitors at present who can affect the company's order winning capability in India, but it may not be the same in near future. It was also observed that the top management was not clear about the successful adoption of SDP. The employee involvement and empowerment was also an issue in implementing SDP. Ideally the company's sourcing strategy should consider many dimensions like cost, quality, responsiveness, reliability and flexibility; but cost was the dominant parameter in its sourcing strategy which was affecting its SDPs. After gaining thorough understanding of company's SDP environment, second phase of the methodology (section 2.1.2) was applied. In this phase, numerous SDPEs were identified through brainstorming sessions held in the case company. The accountancy and relevancy of SDPEs were assessed with respect to the defined SDP environment of the case company. Finally, twenty SDPEs listed in Table 2.1.3 were selected. Twelve experts (with a minimum of 7 years of experience in the case company) were drawn for further analysis of the SDPEs. In the third phase (see section 2.1.3), twelve experts' qualitative opinions regarding mutual influence of the selected twenty SDPEs were collected using linguistic variables (i.e. no, low, medium, high and very high influence) to obtain pair wise comparison matrix. Table 2.1.4 shows the linguistic response matrix collected from the 7th expert. In the fourth phase (see section 2.1.4), these twelve linguistic response matrices were used as inputs to a user-friendly software program developed in MATLAB 7.10.0 (R2010a) for implementing Fuzzy DEMATEL algorithm. In the software program, the linguistic response matrices from all twelve experts were quantified to obtain direct relationship matrices. Table 2.1.5 shows quantified direct relationship matrix for the 7th expert. The direct relationship matrix of each expert was fuzzified to develop *FDRM* on the basis of Table 2.1.2. Table 2.1.6 shows the *FDRM* for the 7th expert. The *FDRM* was defuzzified using a defuzzification technique (i.e. CFCS as mentioned in step 2 of section 2.1.4) to obtain *DDRM* for each expert. Table 2.1.7 shows the *DDRM* for 7th expert. All the obtained twelve *DDRMs* were averaged to form *ADRM* and is shown in Table 2.1.8.

The normalized *ADRM* and *TRM* were calculated (as mentioned in step 4 and step 5 of section 2.1.4 respectively) and are mentioned in Table 2.1.9 and Table 2.1.10 respectively. Then, the R vector (see Table 2.1.11) and C vector (see Table 2.1.11) were calculated in order to determine $R + C$ vector (see Table 2.1.11) and $R - C$ vector (see Table 2.1.11). The prioritization (i.e. degree of importance) of SDPEs was carried out on the basis of $R + C$ vector while the segregation of SDPEs into cause and effect groups was carried out on the basis of $R - C$ vector (see Table 2.1.12 and Table 2.1.13). The causal diagram (see Figure 2.1.2) was plotted (as mentioned in step 8 of section 2.1.4) to know the distribution of SDPEs with respect to degree of importance and degree of cause or effect. The threshold value was set as 0.0314 (the average of *TRM*) on the basis of twelve experts' judgment. This threshold value was deducted from the elements of *TRM* to obtain *significant TRM* (see Table 2.1.14). In the *significant TRM,* the negative elements were eliminated to obtain *reduced TRM* (see Table 2.1.15). For each SDPE with respect to other SDPEs, the strength of influencing and influenced were retrieved from the *reduced TRM* (see Table 2.1.15). In order to present this, *TMC's* strength of influencing and influenced with respect to other SDPEs is shown in Table 2.1.16. Using PARETO analysis, the list of SDPEs influencing each SDPE is shown in Table 2.1.17 while the list of SDPEs influenced by each SDPE is shown in Table 2.1.18 respectively. This *reduced TRM* also forms the basis for developing the impact relationship map (refer step 9 of section 2.1.4).

Table 2.1.3 Selected SDPEs with brief description

SDPE	Description	Sources
PFC	It indicates the manufacture's pressure on supplies to adopt certifications (quality, maintenance, human resource, environment, safety etc.)	(Prahinski and Benton, 2004); (Prahinski and Fan, 2007); (Govindan et al., 2010); (Goedhuys and Sleuwaegen, 2013); (Ehrgott et al., 2013); (Dou et al., 2014a); (Blonska et al., 2013); (Brashear Alejandro et al., 2013); (Sucky and Durst, 2013); and (Mitra and Datta, 2013).
SCMi	It indicates the degree of suppliers' eagerness/ willingness to accept and follow manufacturer's proposed initiatives of SD.	(Carr et al., 2008); (New, 2013); and (Egels-Zandén, 2014).
MUV	Competent employees visit from either side to resolve problems, identify opportunities to improve and so on.	(Krause and Ellram, 1997a); (Krause and Ellram, 1997b); (Sucky and Durst, 2013); (Routroy and Pradhan, 2013a); (Ecel et al., 2013); and (Hoejmose et al., 2013).
SMG	It represents how systematically SD activities are carried out with a clear planning, implementing, controlling, monitoring, improving and transforming systems.	(Ahmed and Hendry, 2012); (Hoejmose et al., 2013); and (Blonska et al., 2013).
ISMa	It indicates the level of importance attached to SD in other supply chain segments.	(Yang et al., 2013); (Potter and Lawson, 2013); (Brashear Alejandro et al., 2013); and (Praxmarer-Carus et al., 2013).
SUR	These are the tools used by the manufacturer to encourage motivate and recognize the suppliers for their efforts to implement the SDP.	(Dou et al., 2014a); and (Routroy and Pradhan, 2013a).
TAD	The manufacturer set targets for suppliers along various dimensions where the improvement is expected through SDP.	(Krause et al., 1998); (Handfield et al., 2000); (Sako, 2004); (Wagner, 2006); (Fu et al., 2012); and (Dou et al., 2014a).
TMC	It refers to top management's seriousness in implementing SDP.	(Fu et al., 2012); (Li et al., 2012); (Dou et al., 2014a); and (Routroy and Pradhan, 2013a).
TKT	It represents expertise, experience, technology and knowledge transfer from both sides to enhance the capability.	(Dyer and Nobeoka, 2000); (Argote et al., 2000); (Modi and Mabert, 2007); (Giannakis, 2008); (Lu et al., 2012); and (Rosell, 2013).
TRU	It is to convince each other that SDP activities are for win-win situations but not with any ulterior and exploitative motives.	(Park et al., 2010); (Liao et al., 2013); (Routroy and Pradhan, 2013a); (Blonska et al., 2013); and (Nagati and Rebolledo, 2013).
ECI	It is a platform should be created effectively to enhance the eagerness and commitment of employees on both sides.	(Simpson et al., 2002); (Humphreys et al., 2011); (Prahinski and Benton, 2004); (Liao et al., 2013); (Potter and Lawson, 2013); and (Nagati and Rebolledo, 2013).
PRS	These are the profit and risk sharing mechanisms designed and developed to ensure win-win situation for both the parties.	(Hallikas et al., 2004); and (Liao et al., 2013).
IVT	It is to visualize real situation or effectiveness of SDP implementation and allows taking necessary steps if required.	(Lascelles and Dale, 1990); (Krause and Ellram, 1997a); and (Wu et al., 2013).
PMB	It indicates proximity and accessibility of the supplier to the manufacturer.	(Kumar et al., 2012); (Wu et al., 2013); and (Routroy and Pradhan, 2013a).
PCEx	It indicates the supplier's consistency in completely fulfilling the manufacturer's proposed initiatives.	(Wu et al., 2013); and (Routroy and Pradhan, 2013a).
SSC	It indicates the conditions of supplier's supplier (to be considered for development) in terms of financial stability, technological capability, reputation, capacity etc.	(Wu et al., 2013); and (Routroy and Pradhan, 2013a).
PRMt	It represents the dealings/ transactions carried out in a professionalized way, on both manufacturer and supplier sides.	(Narasimhan et al., 2008); (Raafat et al., 2012); (Wu et al., 2013); and (Nagati and Rebolledo, 2013).
MIM	It indicates that the supplier is made to participate in SD activities through inspiration from others/ by emulating others.	(Narasimhan et al., 2008); (Raafat et al., 2012); (Wu et al., 2013); and (Nagati and Rebolledo, 2013).
NOM	It indicates that the supplier is made to participate in SD activities through the rules framed by the manufacturer.	(Narasimhan et al., 2008); (Raafat et al., 2012); (Wu et al., 2013); and (Nagati and Rebolledo, 2013).
SSD	It is the based criticality of product / service offered, capabilities, quality, geographical uncertainty, management attitude and environmental issues...etc.	(De Boer et al., 2001); (Li et al., 2012); and (Rosell, 2013).

Manufacturer's Pressure on suppliers to follow Certifications (PFC); Supplier's Compliance to Manufacturer's initiatives (SCMi); Mutual site Visits by both supplier and manufacturer personnel (MUV): Scientific Management of SD (SMG); Involvement of SD in Supply Management activities (ISMa); Supplier Rewards/ incentives (SUR) ; Targets set to suppliers Along various Dimensions (TAD); Top management commitment from both manufacturer and supplier sides (TMC); Technology and Knowledge Transfer (TKT); Trust (TRU) ; Employees' Commitment in SD (ECI); Profit and Risk Sharing mechanism (PRS); Information Visibility and Transparency (IVT); Proximity to Manufacturing Base (PMB); Project Completion Exercise (PCEx); Supplier's Supplier Condition (SSC); Professionalization Motive (PRMt); Mimetic Motive (MIM); Normative Motive (NOM); Manufacturer's criteria for Supplier Selection for Development (SSD)

Table 2.1.4 Linguistic Response Matrix of 7th expert

	SSD	PFC	SCMi	MUV	ISMa	SUR	TAD	TMC	SMG	TKT	TRU	ECI	PRS	IVT	MIM	NOM	PRMt	PMB	PCEx	SSC
SSD	0	VH	H	No	No	No	No	VH	H	No	VH	VH	H	H	H	H	H	VH	VH	VH
PFC	No	0	VH	VH	H	No	VL	L	H	H	H	H	No	H	L	VH	H	No	L	L
SCMi	No	H	0	H	VH	VH	L	VH	H	L	VH	VH	No	H	L	L	L	No	VH	L
MUV	No	VH	VH	0	H	H	VH	VH	H	VH	VH	VH	H	VH	L	H	H	No	VH	L
ISMa	No	L	L	L	0	L	L	H	VH	VH	VH	H	H	H	L	L	L	No	H	VL
SUR	No	No	H	L	H	0	VH	VH	H	H	H	VH	L	L	VH	L	H	No	H	L
TAD	No	No	H	H	H	VH	0	H	H	H	L	VH	H	VL	VL	VL	H	No	H	L
TMC	H	H	VH	H	H	VH	H	0	H	H	H	H	VH	L	H	H	H	H	H	H
SMG	No	L	H	H	VH	H	L	L	0	L	H	H	L	H	L	L	H	No	H	L
TKT	No	No	No	H	L	L	L	L	L	0	L	H	L	L	L	No	VL	No	L	No
TRU	No	No	L	H	H	No	No	VH	L	VL	0	L	VH	VH	No	No	No	No	L	No
ECI	No	No	VH	VH	H	H	L	VH	VH	H	VH	0	No	No	No	No	No	No	VH	H
PRS	No	No	H	H	H	H	No	VH	L	No	VH	VH	0	H	L	L	L	No	VH	H
IVT	No	H	H	H	H	L	No	VH	L	L	VH	H	H	0	H	H	H	H	H	H
MIM	No	L	H	H	H	L	L	No	H	H	H	H	H	H	0	No	No	No	H	H
NOM	No	VH	L	L	H	VL	L	H	H	No	H	H	L	H	No	0	No	No	H	H
PRMt	No	H	H	H	H	VL	L	H	H	L	H	H	H	H	No	No	0	No	H	H
PMB	No	VH	VH	VH	H	No	L	VH	H	VH	VH	VH	L	VH	H	H	H	0	VH	H
PCEx	No	H	L	H	VL	H	VL	H	VL	L	VH	H	H	L	H	H	H	No	0	H
SSC	No	L	VL	VL	VL	No	No	VL	No	No	L	L	No	No	No	No	No	No	L	

Note:[(1) Manufacturer's criteria for supplier selection for development: SSD, (2) Manufacturer's pressure on supplier to follow certifications: PFC, (3) Supplier's compliance to manufacturer's initiatives: SCMi, (4) Mutual visits by competent personnel both sides: MUV, (5) Involvement of SD in supply management activities: ISMa, (6) Supplier rewards/ incentives: SUR, (7) Targets set to suppliers along various dimensions: TAD, (8) Top management commitment from both sides: TMC, (9) Scientific management of SD: SMG, (10) Technology and knowledge transfer: TKT, (11) Trust: TRU, (12) Employees commitment in SD: ECI, (13) Profit and risk sharing mechanism: PRS, (14) Information visibility and transparency: IVT, (15) Mimetic motive: MIM, (16) Normative motive: NOM, (17) Professionalization motive: PRMt, (18) Proximity to manufacturing base: PMB, (19) Project completion exercise: PCEx, (20) Supplier's supplier condition: SSC]

Table 2.1.5 Quantified Direct Relationship Matrix of 7th expert

	SSD	PFC	SCMi	MUV	ISMa	SUR	TAD	TMC	SMG	TKT	TRU	ECI	PRS	IVT	MIM	NOM	PRMt	PMB	PCEx	SSC
SSD	0	4	3	0	0	0	0	4	3	0	4	4	3	3	3	3	3	4	4	4
PFC	0	0	4	4	3	0	1	2	3	3	3	3	0	3	2	4	3	0	2	2
SCMi	0	3	0	3	4	4	2	4	3	2	4	4	0	3	2	2	2	0	4	2
MUV	0	4	4	0	3	3	4	4	3	4	4	4	3	4	2	3	3	0	4	2
ISMa	0	2	2	2	0	2	2	3	4	4	4	3	3	3	2	2	2	0	3	1
SUR	0	0	3	2	3	0	4	4	3	3	3	4	2	2	4	2	3	0	3	2
TAD	0	0	3	3	3	4	0	3	3	3	2	4	3	1	1	1	3	0	3	2
TMC	3	3	4	3	3	4	3	0	3	3	3	3	4	2	3	3	3	3	3	3
SMG	0	2	3	3	4	3	2	2	0	2	3	3	2	3	2	2	3	0	3	2
TKT	0	0	0	3	2	2	2	2	2	0	2	3	2	2	2	0	1	0	2	0
TRU	0	0	2	3	3	0	0	4	2	1	0	2	4	4	0	0	0	0	2	0
ECI	0	0	4	4	3	3	2	4	4	3	4	0	0	0	0	0	0	0	4	3
PRS	0	0	3	3	3	3	0	4	2	0	4	4	0	3	2	2	2	0	4	3
IVT	0	3	3	3	3	2	0	4	2	2	4	3	3	0	3	3	3	3	3	3
MIM	0	2	3	3	3	2	2	0	3	3	3	3	3	3	0	0	0	0	3	3
NOM	0	4	2	2	3	1	2	3	3	0	3	3	2	3	0	0	0	0	3	3
PRMt	0	3	3	3	3	1	2	3	3	2	3	3	3	3	0	0	0	0	3	3
PMB	0	4	4	4	3	0	2	4	3	4	4	4	2	4	3	3	3	0	4	3
PCEx	0	3	2	3	1	3	1	3	1	2	4	3	3	2	3	3	3	0	0	3
SSC	0	2	1	1	1	0	0	1	0	0	2	2	0	0	0	0	0	0	2	0

Note:[(1) Manufacturer's criteria for supplier selection for development: SSD, (2) Manufacturer's pressure on supplier to follow certifications: PFC, (3) Supplier's compliance to manufacturer's initiatives: SCMi, (4) Mutual visits by competent personnel both sides: MUV, (5) Involvement of SD in supply management activities: ISMa, (6) Supplier rewards/ incentives: SUR, (7) Targets set to suppliers along various dimensions: TAD, (8) Top management commitment from both sides: TMC, (9) Scientific management of SD: SMG, (10) Technology and knowledge transfer: TKT, (11) Trust: TRU, (12) Employees commitment in SD: ECI, (13) Profit and risk sharing mechanism: PRS, (14) Information visibility and transparency: IVT, (15) Mimetic motive: MIM, (16) Normative motive: NOM, (17) Professionalization motive: PRMt, (18) Proximity to manufacturing base: PMB, (19) Project completion exercise: PCEx, (20) Supplier's supplier condition: SSC]

Table 2.1.6 Fuzzified Direct Relationship Matrix of 7th expert

SSD	(0,0,0.25);(0.75,1.00,1.00);(0.50,0.75,1.00);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0.75,1.00,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00); (0.75,1.00,1.00)
PFC	(0,0,0.25);(0,0,0.25);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0,0,0.25);(0,0.25,0.50);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00); (0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.25,0.50,0.75);(0.25,0.50,0.75)
SCMi	(0,0,0.25);(0.50,0.75,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.75,1.00,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.25,0.50,0.75);(0,0,0.25);(0.75,1.00,1.00);(0.25,0.50,0.75)
MUV	(0,0,0.25);(0.75,1.00,1.00);(0.75,1.00,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.75,1.00,1.00);(0.25,0.50,0.75)
ISMa	(0,0,0.25);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.25,0.50,0.75);(0,0,0.25);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.25,0.50,0.75);(0,0,0.25);(0.50,0.75,1.00);(0,0.25,0.50)
SUR	(0,0,0.25);(0,0,0.25);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.50,0.75,1.00);(0,0,0.25);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.25,0.50,0.75);(0.50,0.75,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.25,0.50,0.75)
TAD	(0,0,0.25);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.50,0.75,1.00);(0,0.25,0.50);(0,0.25,0.50);(0,0.25,0.50);(0.50,0.75,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.25,0.50,0.75)
TMC	(0.50,0.75,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00)
SMG	(0,0,0.25);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0,0,0.25);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.50,0.75,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.25,0.50,0.75)
TKT	(0,0,0.25);(0,0,0.25);(0,0,0.25);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.25,0.50,0.75);(0,0,0.25);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.25,0.50,0.75);(0,0,0.25);(0,0.25,0.50);(0,0,0.25);(0.25,0.50,0.75);(0,0,0.25)
TRU	(0,0,0.25);(0,0,0.25);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0,0,0.25);(0.75,1.00,1.00);(0.25,0.50,0.75);(0,0.25,0.50);(0,0,0.25);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.75,1.00,1.00);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0.25,0.50,0.75);(0,0,0.25)
ECI	(0,0,0.25);(0,0,0.25);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0.75,1.00,1.00);(0.50,0.75,1.00)
PRS	(0,0,0.25);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.75,1.00,1.00);(0.25,0.50,0.75);(0,0,0.25);(0.75,1.00,1.00);(0.75,1.00,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.25,0.50,0.75);(0,0,0.25);(0.75,1.00,1.00);(0.50,0.75,1.00)
IVT	(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0,0,0.25);(0.75,1.00,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00)
MIM	(0,0,0.25);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00)
NOM	(0,0,0.25);(0.75,1.00,1.00);(0.25,0.50,0.75);(0.25,0.50,0.75);(0.50,0.75,1.00);(0,0.25,0.50);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.50,0.75,1.00);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00)
PRMt	(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0.25,0.50);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0.50,0.75,1.00);(0.50,0.75,1.00)
PMB	(0,0,0.25);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.75,1.00,1.00);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0.75,1.00,1.00);(0.50,0.75,1.00)
PCEx	(0,0,0.25);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.50,0.75,1.00);(0,0.25,0.50);(0.50,0.75,1.00);(0,0.25,0.50);(0.50,0.75,1.00);(0,0.25,0.50);(0.25,0.50,0.75);(0.75,1.00,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.25,0.50,0.75);(0.50,0.75,1.00);(0.50,0.75,1.00);(0.50,0.75,1.00);(0,0,0.25);(0,0,0.25);(0.50,0.75,1.00)
SSC	(0,0,0.25);(0.25,0.50,0.75);(0,0.25,0.50);(0,0.25,0.50);(0,0.25,0.50);(0,0,0.25);(0,0,0.25);(0,0.25,0.50);(0,0,0.25);(0,0,0.25);(0.25,0.50,0.75);(0.25,0.50,0.75);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0,0,0.25);(0.25,0.50,0.75);(0,0,0.25)

Table 2.1.7 Defuzzified Direct Relationship Matrix of 7th expert

	SSD	PFC	SCMi	MUV	ISM	SUR	TAD	TMC	SMG	TKT	TRU	ECI	PRS	IVT	MIM	NOM	PRMt	PMB	PCEx	SSC
SSD	0.0333	0.7333	0	0	0.0333	0	0.0333	0	0	0	0	0.7333	0	0	0	0	0	0	0.0333	0
PFC	0.0333	0.0333	0.7333	0	0	0.2667	0	0	0.7333	0.7333	0	0	0	0	0	0	0	0.0333	0	0
SCMi	0.0333	0	0	0.5	0	0	0	0.9667	0	0	0	0	0	0	0	0	0.7333	0	0	0
MUV	0.0333	0.0333	0.7333	0.5	0.5	0.9667	0	0.9667	0	0	0.7333	0.7333	0	0	0	0.7333	0.0333	0	0	0
ISMa	0.0333	0.0333	0.7333	0.7333	0.7333	0.5	0	0	0.7333	0	0	0.0333	0	0	0.7333	0	0	0	0	0
SUR	0.0333	0.0333	0	0.0333	0	0	0.5	0	0	0	0	0	0	0.5	0	0.7333	0	0	0	0
TAD	0.0333	0.7333	0	0	0	0	0	0	0	0.7333	0	0	0.7333	0	0	0	0	0	0	0
TMC	0.7333	0.7333	0.5	0.7333	0.9667	0.0333	0.7333	0	0.7333	0	0.5	0.7333	0	0	0.7333	0	0	0	0	0
SMG	0.0333	0	0.0333	0	0	0	0	0	0.0333	0	0.9667	0	0	0	0.0333	0	0	0	0	0
TKT	0.0333	0.5	0.5	0.7333	0.7333	0.2667	0.0333	0.7333	0.5	0.5	0.7333	0	0	0.7333	0	0	0	0	0	0
TRU	0.0333	0	0.7333	0	0.0333	0	0	0	0.2667	0	0	0	0	0	0	0	0	0	0	0
ECI	0.0333	0.9667	0.7333	0.9667	0	0.5	0.9667	0.7333	0	0.7333	0	0	0.9667	0.0333	0	0	0	0	0	0
PRS	0.0333	0.5	0	0	0	0	0.2667	0.7333	0	0	0	0	0	0	0	0	0	0	0	0
IVT	0.0333	0.7333	0.9667	0	0	0.7333	0	0.9667	0	0	0	0.5	0	0	0	0	0	0	0	0
MIM	0.0333	0.7333	0.7333	0.7333	0.2667	0	0.7333	0	0	0.7333	0	0	0.0333	0	0	0	0	0	0	0
NOM	0.0333	0.9667	0.7333	0.7333	0.2667	0	0.7333	0.9667	0.7333	0.0333	0.9667	0	0.0333	0	0	0	0	0	0	0
PRMt	0.0333	0	0.5	0.0333	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PMB	0.0333	0.7333	0	0.7333	0.0333	0	0	0	0	0.9667	0	0.7333	0	0	0	0	0	0	0	0
PCEx	0.0333	0.7333	0	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SSC	0.0333	0.5	0.2667	0.2667	0.2667	0.0333	0.0333	0.2667	0.0333	0.0333	0.5	0.5	0.0333	0.0333	0.0333	0.0333	0.0333	0.0333	0.5	0.0333

Table 2.1.8 Average Defuzzified Direct Relationship Matrix

	SSD	PFC	SCMi	MUV	ISMa	SUR	TAD	TMC	SMG	TKT	TRU	ECI	PRS	IVT	MIM	NOM	PRMt	PMB	PCEx	SSC
SSD	0	0.8694	0	0	0.0333	0	0.0333	0	0	0	0	0.7917	0	0	0	0	0	0	0.0333	0
PFC	0.0333	0	0.7528	0	0	0.1889	0	0	0.6944	0.85	0	0	0	0	0	0	0	0.0528	0	0
SCMi	0.0333	0	0	0.3056	0	0	0	0.8694	0	0	0	0	0	0	0	0	0.7917	0	0	0
MUV	0.0333	0.3833	0.3639	0	0.6361	0.9472	0	0.9667	0	0	0.8694	0.3639	0	0	0	0.8306	0.0333	0	0	0
ISMa	0.0333	0.0333	0.8306	0.6167	0	0.8306	0	0	0.4806	0	0	0.0333	0	0	0.7917	0	0	0	0	0
SUR	0.0333	0.0333	0	0.0333	0	0	0.5778	0	0	0	0	0	0	0.3056	0	0.7917	0	0	0	0
TAD	0.0333	0.7917	0	0	0	0	0	0	0	0.8889	0	0	0.7917	0	0	0	0	0	0	0
TMC	0.8889	0.8694	0.6167	0.7917	0.9667	0.0333	0.8694	0	0.85	0	0.2278	0.9472	0	0	0.8306	0	0	0	0	0
SMG	0.0333	0	0.0333	0	0	0	0	0	0	0	0.9667	0	0	0	0.0333	0	0	0	0	0
TKT	0.0333	0.2083	0.5778	0.8306	0.85	0.0917	0.0722	0.7917	0.2861	0	0.85	0	0	0.8111	0	0	0	0	0	0
TRU	0.0333	0	0.8306	0	0.0917	0	0	0	0.7917	0	0	0	0	0	0	0	0	0	0	0
ECI	0.1111	0.9472	0.85	0.9667	0	0.5778	0.7333	0.8889	0	0.5972	0	0	0.9667	0.1111	0	0	0	0	0	0
PRS	0.0333	0.8111	0	0	0	0	0.5194	0.8694	0	0	0	0	0	0	0	0	0	0	0	0
IVT	0.0333	0.5972	0.9667	0	0	0.8889	0	0.9278	0	0	0	0.6167	0	0	0	0	0	0	0	0
MIM	0.0333	0.7917	0.2667	0.6167	0.7917	0	0.8306	0	0	0.8694	0	0	0.1694	0	0	0	0	0	0	0
NOM	0.0333	0.9472	0.8694	0.7917	0.0917	0	0.8111	0.9083	0.4417	0.0722	0.9667	0	0.0333	0	0	0	0	0	0	0
PRMt	0.0333	0	0.7722	0.0333	0	0.3833	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PMB	0.0333	0.8111	0	0.85	0.2472	0	0	0	0	0.9667	0	0.85	0	0	0	0	0	0	0	0
PCEx	0.0333	0.8306	0	0	0.3639	0.3444	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SSC	0.0333	0.1694	0.325	0.0917	0.0528	0.1889	0.0722	0.325	0.0333	0.0333	0.1889	0.4028	0.0333	0.0333	0.0333	0.0333	0.0333	0.4222	0.3639	0

Table 2.1.9 Normalized Average Direct Relationship Matrix

	SSD	PFC	SCMi	MUV	ISMa	SUR	TAD	TMC	SMG	TKT	TRU	ECI	PRS	IVT	MIM	NOM	PRMt	PMB	PCEx	SSC
SSD	0	0.0956	0	0	0.0037	0	0.0037	0	0	0	0	0.087	0	0	0	0	0	0	0.0037	0
PFC	0.0037	0	0.0828	0	0	0.0208	0	0	0.0764	0.0935	0	0	0	0	0	0	0	0.0058	0	0
SCMi	0.0037	0	0	0.0336	0	0	0	0.0956	0	0	0	0	0	0	0	0	0.087	0	0	0
MUV	0.0037	0.0422	0.04	0	0.0699	0.1042	0	0.1063	0	0	0.0956	0.04	0	0	0	0.0913	0.0037	0	0	0
ISMa	0.0037	0.0037	0.0913	0.0678	0	0.0913	0	0	0.0528	0	0	0.0037	0	0	0.087	0	0	0	0	0
SUR	0.0037	0.0037	0	0.0037	0	0	0.0635	0	0	0	0	0	0	0.0336	0	0.087	0	0	0	0
TAD	0.0037	0.087	0	0	0	0	0	0	0	0.0977	0	0	0.087	0	0	0	0	0	0	0
TMC	0.0977	0.0956	0.0678	0.087	0.1063	0.0037	0.0956	0	0.0935	0	0.025	0.1042	0	0	0.0913	0	0	0	0	0
SUM	0.0037	0	0.0037	0	0	0	0	0	0	0	0.1063	0	0	0	0.0037	0	0	0	0	0
TKT	0.0037	0.0229	0.0635	0.0913	0.0935	0.0101	0.0079	0.087	0.0315	0	0.0935	0	0	0.0892	0	0	0	0	0	0
TRU	0.0037	0	0.0913	0	0.0101	0	0	0	0.087	0	0	0	0	0	0	0	0	0	0	0
ECI	0.0122	0.1042	0.0935	0.1063	0	0.0635	0.0806	0.0977	0	0.0657	0	0	0.1063	0.0122	0	0	0	0	0	0
PRS	0.0037	0.0892	0	0	0	0	0.0571	0.0956	0	0	0	0	0	0	0	0	0	0	0	0
IVT	0.0037	0.0657	0.1063	0	0	0.0977	0	0.102	0	0	0	0.0678	0	0	0	0	0	0	0	0
MIM	0.0037	0.087	0.0293	0.0678	0.087	0	0.0913	0	0	0.0956	0	0	0.0186	0	0	0	0	0	0	0
NOM	0.0037	0.1042	0.0956	0.087	0.0101	0	0.0892	0.0999	0.0486	0.0079	0.1063	0	0.0037	0	0	0	0	0	0	0
PRMt	0.0037	0	0.0849	0.0037	0	0.0422	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PMB	0.0037	0.0892	0	0.0935	0.0272	0	0	0	0	0.1063	0	0.0935	0	0	0	0	0	0	0	0
PCEx	0.0037	0.0913	0	0	0.04	0.0379	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SSC	0.0037	0.0186	0.0357	0.0101	0.0058	0.0208	0.0079	0.0357	0.0037	0.0037	0.0208	0.0443	0.0037	0.0037	0.0037	0.0037	0.0037	0.0464	0.04	0

Table 2.1.10 Total Relationship Matrix

	SSD	PFC	SCMi	MUV	ISMa	SUR	TAD	TMC	SMG	TKT	TRU	ECI	PRS	IVT	MIM	NOM	PRMt	PMB	PCEx	SSC
SSD	0.0035	0.1111	0.0224	0.0143	0.0084	0.011	0.0143	0.0156	0.0115	0.018	0.0049	0.0899	0.0108	0.0031	0.0022	0.0023	0.002	0.0006	0.0037	0
PFC	0.0073	0.0087	0.0977	0.0166	0.0131	0.0265	0.0056	0.0214	0.0847	0.0961	0.0205	0.0048	0.0011	0.0095	0.0034	0.0038	0.0086	0.0059	0	0
SCMi	0.0152	0.0184	0.0233	0.0483	0.0163	0.0121	0.0138	0.1058	0.0134	0.0051	0.0098	0.0144	0.003	0.001	0.0111	0.0055	0.0893	0.0001	0.0001	0
MUV	0.021	0.0841	0.0969	0.0409	0.0935	0.1243	0.0382	0.1395	0.0406	0.0184	0.1203	0.0588	0.0104	0.0065	0.021	0.1059	0.0122	0.0005	0.0001	0
ISMa	0.0083	0.0245	0.1095	0.0853	0.0182	0.1042	0.02	0.0244	0.0608	0.0138	0.0183	0.0108	0.0046	0.0049	0.0911	0.0169	0.0098	0.0001	0	0
SUR	0.0067	0.0265	0.0195	0.0158	0.0053	0.0067	0.0748	0.0182	0.0099	0.0111	0.0135	0.0055	0.0075	0.0349	0.0022	0.0891	0.0018	0.0002	0	0
TAD	0.0075	0.1036	0.0222	0.0147	0.0142	0.0075	0.0095	0.0233	0.0156	0.109	0.014	0.0045	0.0884	0.01	0.0034	0.002	0.002	0.0006	0	0
TMC	0.108	0.1556	0.1282	0.131	0.1353	0.0427	0.1264	0.0471	0.1241	0.0456	0.0579	0.1248	0.0263	0.007	0.1079	0.0157	0.0116	0.0009	0.0004	0
SUM	0.0044	0.0012	0.0143	0.0012	0.0018	0.0004	0.0006	0.0016	0.0097	0.0006	0.1075	0.0006	0.0002	0.0001	0.004	0.0001	0.0012	0	0	0
TKT	0.0194	0.0583	0.1198	0.1215	0.1199	0.0466	0.029	0.1266	0.0655	0.0123	0.118	0.0265	0.0058	0.0922	0.0222	0.0152	0.0109	0.0003	0.0001	0
TRU	0.0055	0.0024	0.0959	0.0054	0.0119	0.0022	0.0016	0.0101	0.0898	0.0007	0.0105	0.0018	0.0004	0.0002	0.0023	0.0007	0.0084	0	0	0
ECI	0.0314	0.1592	0.1439	0.142	0.0373	0.0911	0.1144	0.1534	0.0353	0.0954	0.0323	0.0262	0.1194	0.0241	0.0174	0.0209	0.013	0.0009	0.0001	0
PRS	0.0151	0.1112	0.0223	0.0149	0.0149	0.0069	0.0703	0.1034	0.0204	0.0192	0.0082	0.0129	0.0077	0.0021	0.0108	0.002	0.002	0.0006	0.0001	0
IVT	0.0196	0.0979	0.14	0.0308	0.0195	0.112	0.0299	0.1317	0.0231	0.0191	0.0118	0.085	0.0119	0.0065	0.0138	0.0126	0.0123	0.0006	0.0001	0
MIM	0.0097	0.1137	0.0686	0.0941	0.1097	0.0255	0.1016	0.0328	0.0239	0.1181	0.0246	0.0093	0.0287	0.0115	0.0126	0.0108	0.0063	0.0007	0	0
NOM	0.0203	0.1408	0.1443	0.1139	0.0385	0.0214	0.1088	0.134	0.0873	0.0348	0.1344	0.0208	0.0157	0.0041	0.0159	0.0123	0.013	0.0008	0.0001	0
PRMt	0.0053	0.0034	0.0881	0.0086	0.002	0.044	0.0045	0.0103	0.0017	0.001	0.0019	0.002	0.0006	0.0016	0.0011	0.0046	0.0077	0	0	0
PMB	0.0115	0.12	0.047	0.1273	0.0539	0.0303	0.0184	0.0435	0.0233	0.1272	0.0291	0.1053	0.013	0.0137	0.0087	0.0143	0.0046	0.0007	0	0
PCEx	0.0049	0.0945	0.0141	0.0056	0.0422	0.0448	0.0042	0.0037	0.0106	0.0098	0.0031	0.0014	0.0006	0.0024	0.004	0.0044	0.0013	0.0005	0	0
SSC	0.0113	0.0462	0.0585	0.0321	0.02	0.0335	0.0226	0.0549	0.0171	0.02	0.0299	0.0572	0.0119	0.0073	0.0105	0.0095	0.0089	0.0467	0.0401	0

Table 2.1.11 Prioritization of SDPEs

Criteria	SSD	PFC	SCMi	MUV	ISMa	SUR	TAD	TMC	SMG	TKT	TRU	ECI	PRS	IVT	MIM	NOM	PRMt	PMB	PCEx	SSC
R	0.3496	0.4354	0.4058	1.033	0.6256	0.3491	0.4521	1.3965	0.1495	1.01	0.2498	1.2578	0.445	0.7781	0.8022	1.061	0.1886	0.7918	0.2522	0.5382
C	0.3358	1.4811	1.4767	1.0644	0.776	0.7938	0.8085	1.2012	0.7682	0.7755	0.7705	0.6623	0.3682	0.2426	0.3658	0.3483	0.2268	0.0608	0.0449	0
R + C	0.6854	1.9165	1.8825	2.0974	1.4015	1.1429	1.2607	2.5977	0.9177	1.7856	1.0203	1.9202	0.8132	1.0207	1.1679	1.4093	0.4155	0.8527	0.2971	0.5382
R – C	0.0139	-1.0457	-1.0709	-0.0313	-0.1504	-0.4448	-0.3564	0.1953	-0.6186	0.2345	-0.5207	0.5955	0.0768	0.5355	0.4364	0.7127	-0.0382	0.731	0.2073	0.5382

Table 2.1.12 Importance of SDPEs

SDPEs	TMC	MUV	ECI	PFC	SCMi	TKT	NOM	ISMa	TAD	MIM	SUR	IVT	TRU	SMG	PMB	PRS	SSD	SSC	PRMt	PCEx
R + C	2.5977	2.0974	1.9202	1.9165	1.8825	1.7856	1.4093	1.4015	1.2607	1.1679	1.1429	1.0207	1.0203	0.918	0.853	0.813	0.685	0.538	0.415	0.297
Ranking	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Table 2.1.13 Cause and effect groups of SDPEs

SDPEs	PMB	NOM	ECI	SSC	IVT	MIM	TKT	PCEx	TMC	PRS	SSD	MUV	PRMt	ISMa	TAD	SUR	TRU	SMG	PFC	SCMi
R – C	0.731	0.713	0.596	0.538	0.535	0.436	0.234	0.207	0.195	0.077	0.014	-0.031	-0.038	-0.15	-0.36	-0.45	-0.52	-0.62	-1.05	-1.07
Grouping	Cause group of SDPEs											Effect group of SDPEs								

Table 2.1.14 Significant Total Relationship Matrix

	SSD	PFC	SCMi	MUV	ISMa	SUR	TAD	TMC	SMG	TKT	TRU	ECI	PRS	IVT	MIM	NOM	PRMt	PMB	PCEx	SSC
SSD	-0.0279	0.0797	-0.009	-0.0171	-0.023	-0.0204	-0.0171	-0.0158	-0.0199	-0.0135	-0.0265	0.0584	-0.0206	-0.0284	-0.0292	-0.0292	-0.0294	-0.0308	-0.0278	-0.0314
PFC	-0.0241	-0.0227	0.0663	-0.0149	-0.0183	-0.0049	-0.0258	-0.01	0.0533	0.0647	-0.0109	-0.0267	-0.0304	-0.0219	-0.028	-0.0276	-0.0229	-0.0256	-0.0314	-0.0314
SCMi	-0.0163	-0.013	-0.0082	0.0169	-0.0151	-0.0193	-0.0176	0.0743	-0.018	-0.0263	-0.0217	-0.017	-0.0285	-0.0304	-0.0203	-0.026	0.0578	-0.0313	-0.0314	-0.0314
MUV	-0.0104	0.0527	0.0655	0.0094	0.0621	0.0929	0.0067	0.108	0.0092	-0.0131	0.0889	0.0274	-0.0211	-0.0249	-0.0104	0.0744	-0.0192	-0.0309	-0.0314	-0.0314
ISMa	-0.0231	-0.007	0.0781	0.0539	-0.0133	0.0728	-0.0114	-0.007	0.0294	-0.0176	-0.0131	-0.0207	-0.0268	-0.0266	0.0597	-0.0146	-0.0216	-0.0313	-0.0314	-0.0314
SUR	-0.0247	-0.0049	-0.012	-0.0156	-0.0261	-0.0247	0.0434	-0.0132	-0.0216	-0.0203	-0.0179	-0.0259	-0.024	0.0035	-0.0293	0.0576	-0.0297	-0.0313	-0.0314	-0.0314
TAD	-0.0239	0.0722	-0.0092	-0.0168	-0.0172	-0.0239	-0.0219	-0.0081	-0.0158	0.0776	-0.0174	-0.027	0.057	-0.0214	-0.028	-0.0294	-0.0294	-0.0308	-0.0314	-0.0314
TMC	0.0765	0.1242	0.0967	0.0996	0.1039	0.0112	0.095	0.0157	0.0927	0.0142	0.0264	0.0933	-0.0051	-0.0244	0.0764	-0.0157	-0.0198	-0.0305	-0.031	-0.0314
SUM	-0.0271	-0.0303	-0.0172	-0.0303	-0.0297	-0.031	-0.0308	-0.0298	-0.0217	-0.0308	0.0761	-0.0308	-0.0312	-0.0314	-0.0274	-0.0313	-0.0302	-0.0314	-0.0314	-0.0314
TKT	-0.012	0.0269	0.0884	0.0901	0.0885	0.0152	-0.0024	0.0951	0.034	-0.0191	0.0865	-0.005	-0.0256	0.0607	-0.0092	-0.0163	-0.0206	-0.0311	-0.0314	-0.0314
TRU	-0.0259	-0.029	0.0645	-0.026	-0.0195	-0.0292	-0.0299	-0.0213	0.0583	-0.0307	-0.021	-0.0296	-0.0311	-0.0313	-0.0291	-0.0307	-0.0231	-0.0314	-0.0314	-0.0314
ECI	-0.0001	0.1277	0.1125	0.1106	0.0059	0.0597	0.0829	0.122	0.0039	0.0639	0.0009	-0.0052	0.088	-0.0073	-0.014	-0.0105	-0.0184	-0.0305	-0.0313	-0.0314
PRS	-0.0163	0.0797	-0.0091	-0.0165	-0.0165	-0.0245	0.0389	0.072	-0.0111	-0.0122	-0.0232	-0.0185	-0.0237	-0.0293	-0.0206	-0.0295	-0.0294	-0.0308	-0.0314	-0.0314
IVT	-0.0119	0.0664	0.1086	-0.0006	-0.0119	0.0806	-0.0016	0.1003	-0.0084	-0.0123	-0.0196	0.0536	-0.0195	-0.0249	-0.0176	-0.0189	-0.0191	-0.0309	-0.0314	-0.0314
MIM	-0.0217	0.0823	0.0372	0.0627	0.0782	-0.006	0.0701	0.0013	-0.0075	0.0867	-0.0069	-0.0222	-0.0027	-0.0199	-0.0188	-0.0206	-0.0251	-0.0308	-0.0314	-0.0314
NOM	-0.0112	0.1093	0.1129	0.0825	0.0071	-0.01	0.0774	0.1026	0.0558	0.0034	0.1029	-0.0107	-0.0157	-0.0274	-0.0155	-0.0192	-0.0184	-0.0306	-0.0314	-0.0314
PRMt	-0.0261	-0.028	0.0567	-0.0228	-0.0294	0.0125	-0.0269	-0.0211	-0.0297	-0.0304	-0.0296	-0.0294	-0.0308	-0.0298	-0.0303	-0.0268	-0.0237	-0.0314	-0.0314	-0.0314
PMB	-0.0199	0.0885	0.0156	0.0959	0.0224	-0.0011	-0.013	0.012	-0.0081	0.0958	-0.0023	0.0738	-0.0184	-0.0178	-0.0227	-0.0172	-0.0269	-0.0307	-0.0314	-0.0314
PCEx	-0.0265	0.0631	-0.0173	-0.0259	0.0107	0.0133	-0.0272	-0.0278	-0.0208	-0.0216	-0.0283	-0.03	-0.0308	-0.029	-0.0274	-0.027	-0.0302	-0.0309	-0.0314	-0.0314
SSC	-0.0202	0.0147	0.0271	0.0007	-0.0114	0.0021	-0.0088	0.0235	-0.0144	-0.0114	-0.0015	0.0258	-0.0195	-0.0242	-0.0209	-0.0219	-0.0225	0.0153	0.0086	-0.0314

Table 2.1.15 Reduced Total Relationship Matrix

	SSD	PFC	SCMi	MUV	ISMa	SUR	TAD	TMC	SMG	TKT	TRU	ECI	PRS	IVT	MIM	NOM	PRMt	PMB	PCEx	SSC
SSD	0	0.0797	0	0	0	0	0	0	0	0	0	0.0584	0	0	0	0	0	0	0	0
PFC	0	0	0.0663	0	0	0	0	0	0.0533	0.0647	0	0	0	0	0	0	0	0	0	0
SCMi	0	0	0	0.0169	0	0	0	0.0743	0	0	0	0	0	0	0	0	0.0578	0	0	0
MUV	0	0.0527	0.0655	0.0094	0.0621	0.0929	0.0067	0.108	0.0092	0	0.0889	0.0274	0	0	0	0.0744	0	0	0	0
ISMa	0	0	0.0781	0.0539	0	0.0728	0	0	0.0294	0	0	0	0	0	0.0597	0	0	0	0	0
SUR	0	0	0	0	0	0	0.0434	0	0	0	0	0	0	0.0035	0	0.0576	0	0	0	0
TAD	0	0.0722	0	0	0	0	0	0	0	0.0776	0	0	0.057	0	0	0	0	0	0	0
TMC	0.0765	0.1242	0.0967	0.0996	0.1039	0.0112	0.095	0.0157	0.0927	0.0142	0.0264	0.0933	0	0	0.0764	0	0	0	0	0
SUM	0	0	0	0	0	0	0	0	0	0	0.0761	0	0	0	0	0	0	0	0	0
TKT	0	0.0269	0.0884	0.0901	0.0885	0.0152	0	0.0951	0.034	0	0.0865	0	0	0.0607	0	0	0	0	0	0
TRU	0	0	0.0645	0	0	0	0	0	0.0583	0	0	0	0	0	0	0	0	0	0	0
ECI	0	0.1277	0.1125	0.1106	0.0059	0.0597	0.0829	0.122	0.0039	0.0639	0.0009	0	0.088	0	0	0	0	0	0	0
PRS	0	0.0797	0	0	0	0	0.0389	0.072	0	0	0	0	0	0	0	0	0	0	0	0
IVT	0	0.0664	0.1086	0	0	0.0806	0	0.1003	0	0	0	0.0536	0	0	0	0	0	0	0	0
MIM	0	0.0823	0.0372	0.0627	0.0782	0	0.0701	0.0013	0	0.0867	0	0	0	0	0	0	0	0	0	0
NOM	0	0.1093	0.1129	0.0825	0.0071	0	0.0774	0.1026	0.0558	0.0034	0.1029	0	0	0	0	0	0	0	0	0
PRMt	0	0	0.0567	0	0	0.0125	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PMB	0	0.0885	0.0156	0.0959	0.0224	0	0	0.012	0	0.0958	0	0.0738	0	0	0	0	0	0	0	0
PCEx	0	0.0631	0	0	0.0107	0.0133	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SSC	0	0.0147	0.0271	0.0007	0	0.0021	0	0.0235	0	0	0	0.0258	0	0	0	0	0	0.0153	0.0086	0

Table 2.1.16 TMC's strength of influencing on and influenced by other SDPEs

TMC			
Criteria	Strength of Influence	Criteria	Strength of Influenced
PFC	0.1242	ECI	0.122
ISMa	0.1039	MUV	0.108
MUV	0.0996	NOM	0.1026
SCMi	0.0967	IVT	0.1003
TAD	0.0950	TKT	0.0951
ECI	0.0933	SCMi	0.0743
SMG	0.0927	PRS	0.072
SSD	0.0765	SSC	0.0235
MIM	0.0764	TMC	0.0157
TRU	0.0264	PMB	0.012
TMC	0.0157	MIM	0.0013
TKT	0.0142	-	-
SUR	0.0112	-	-

Table 2.1.17 List of SDPEs influencing each SDPE

SDPEs	Number of SDPEs Influencing	SDPEs Influencing the SDPE	Prominent SDPEs Influencing the SDPE
TMC	11	ECI, MUV, NOM, IVT, TKT, SCMi, PRS, SSC, TMC, PMB, MIM	ECI, MUV, NOM, IVT, TKT
MUV	10	ECI, TMC, PMB, TKT, NOM, MIM, ISMa, SCMi, MUV, SSC	ECI, TMC, PMB, TKT, NOM
SCMi	13	NOM, ECI, IVT, TMC, TKT, ISMa, PFC, MUV, TRU, PRMt, MIM, SSC, PMB	NOM, ECI, IVT, TMC, TKT, ISMa, PFC, MUV
ECI	6	TMC, PMB, SSD, IVT, MUV, SSC	TMC, PMB, SSD
PFC	13	ECI, TMC, NOM, PMB, MIM, SSD, PRS, TAD, IVT, PCEx, MUV, TKT, SSC	ECI, TMC, NOM, PMB, MIM, SSD, PRS, TAD
TKT	7	PMB, MIM, TAD, PFC, ECI, TMC, NOM	PMB, MIM, TAD, PFC
NOM	2	MUV, SUR	MUV, SUR
ISMa	8	TMC, TKT, MIM, MUV, PMB, PCEx, NOM, ECI	TMC, TKT, MIM
SUR	9	MUV, IVT, ISMa, ECI, TKT, PCEx, PRMt, TMC, SSC	MUV, IVT, ISMa
TAD	7	TMC, ECI, NOM, MIM, SUR, PRS, MUV	TMC, ECI, NOM, MIM
MIM	2	TMC, ISMa	TMC, ISMa
IVT	2	TKT, SUR	TKT
TRU	6	NOM, MUV, TKT, SMG, TMC, ECI	NOM, MUV, TKT
SMG	8	TMC, TRU, NOM, PFC, TKT, ISMa, MUV, ECI	TMC, TRU, NOM, PFC
PMB	1	SSC	SSC
PRS	2	ECI, TAD	ECI, TAD
SSC	NULL	NULL	NULL
SSD	1	TMC	TMC
PRMt	1	SCMi	SCMi
PCEx	1	SSC	SSC

Table 2.1.18 List of SDPEs influenced by each SDPE

SDPEs	Number of SDPEs Influenced	SDPEs Influenced by the SDPE	Prominent SDPEs Influenced by the SDPE
TMC	13	PFC, ISMa, MUV, SCMi, TAD, ECI, SMG, SSD, MIM, TRU, TMC, TKT, SUR	PFC, ISMa, MUV, SCMi, TAD, ECI, SMG
MUV	11	TMC, SCMi, SUR, TRU, ECI, NOM, ISMa, MUV, PFC, TAD, SMG	TMC, SCMi, SUR, TRU, ECI
SCMi	3	TMC, PRMt, MUV	TMC, PRMt
ECI	11	PFC, TMC, SCMi, MUV, PRS, TAD, TKT, SUR, ISMa, SMG, TRU	PFC, TMC, SCMi, MUV, PRS
PFC	3	SCMi, TKT, SMG	SCMi, TKT
TKT	9	TMC, MUV, ISMa, SCMi, TRU, IVT, SMG, PFC, SUR	TMC, MUV, ISMa, SCMi, TRU
NOM	9	SCMi, PFC, TRU, TMC, MUV, TAD, SMG, ISM, TKT	SCMi, PFC, TRU, TMC, MUV
ISMa	5	SCMi, SUR, MIM, MUV, SMG	SCMi, SUR, MIM
SUR	3	NOM, TAD, IVT	NOM
TAD	3	TKT, PFC, PRS	TKT, PFC
MIM	7	TKT, PFC, ISMa, TAD, MUV, SCMi, TMC	TKT, PFC, ISMa, TAD
IVT	5	SCMi, TMC, SUR, PFC, ECI	SCMi, TMC, SUR
TRU	2	SCMi, SMG	SCMi, SMG
SMG	1	TRU	TRU
PMB	7	MUV, TKT, PFC, ECI, ISMa, SCMi, TMC	MUV, TKT, PFC
PRS	3	PFC, TMC, TAD	PFC, TMC
SSC	8	SCMi, ECI, TMC, PMB, PFC, PCEx, SUR, MUV	SCMi, ECI, TMC, PMB
SSD	3	PFC, ECI, SSC	PFC
PRMt	2	SCMi, SUR	SCMi
PCEx	3	PFC, SUR, ISMa	PFC

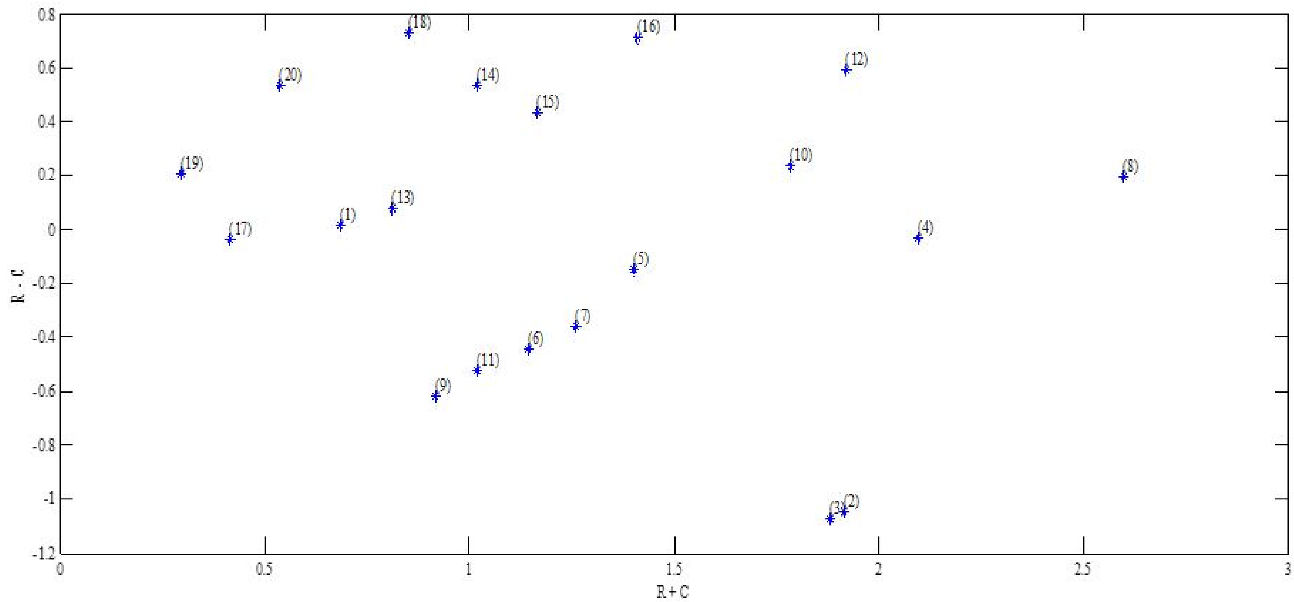


Figure 2.1.2 Causal diagram of SDPEs

2.1.5 Results and Discussion

The proposed methodology for analyzing the SDPEs was applied to the company 'A'. The results obtained are discussed under three sections (i.e. ranking of SDPEs; classification of SDPEs into cause and effect groups; and establishment of interactions for each SDPE using IRM).

2.1.5.1 Ranking of SDPEs

Ranking of SDPEs was carried out on the basis of $R + C$ vector to know the importance of the SDPEs (see Table 2.1.12). In the company A's SDP environment, TMC (Top Management Commitment) was the most important SDPE with the highest $R + C$ value of 2.5977, while PCEx (Project Completion Exercise) was the least important with the lowest $R + C$ value of 0.297. The degree of importance of all SDPEs is shown in Table 2.1.12. A PARETO chart (see Figure 2.1.3) was developed considering the degree of importance to identify the group of important SDPEs. From the Pareto chart, six SDPEs (i.e. TMC, MUV, ECI, PFC, SCMi and TKT) were identified as important SDPEs.

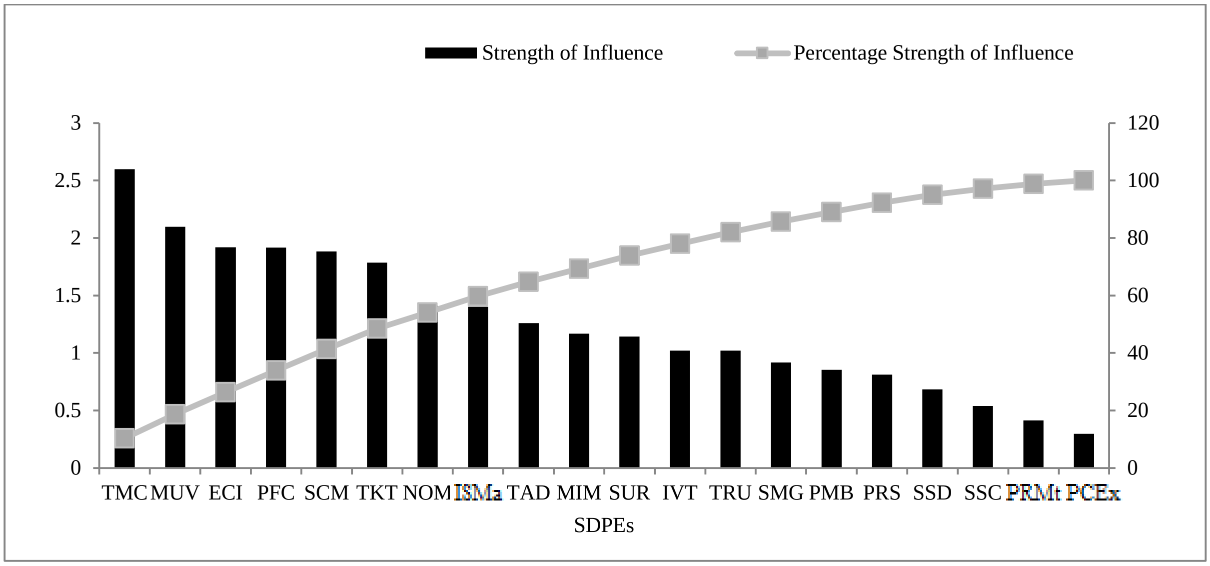


Figure 2.1.3 PARETO chart to identify group of important SDPEs

2.1.5.2 Classification of SDPEs into cause and effect groups

The SDPEs were divided into cause and effect group on the basis of $R - C$ vector (see Table 2.1.14). Eleven SDPEs (i.e. PMB, NOM, ECI, SSC, IVT, MIM, TKT, PCEx, TMC, PRS and SSD) were identified under cause group and the rest nine SDPEs (i.e. SCMi, PFC, SMG, TRU, SUR, TAD, ISMa, PRMt and MUV) were identified under effect group. The most influencing SDPE was PMB (with the highest $R - C$ value of 0.731) whereas the most influenced SDPE was SCMi (with the lowest $R - C$ value of minus 1.071). The PARETO charts (see Figure 2.1.4 and Figure 2.1.5) were also made on the basis of degree of influencing and degree of influenced for both cause and effect groups respectively. The prominent SDPEs of cause group were PMB, NOM, ECI, SSC and IVT whereas the prominent SDPEs of effect group were SCMi, PFC, SMG and TRU. Causal diagram (see Figure 2.1.2) was also made by taking $R + C$ vector values as abscissas and $R - C$ vector values as ordinates on a Cartesian plane (i.e. elemental values of $R + C$ vector were paired up with elemental values of $R - C$ vector to form ordered pairs) to show the distribution of SDPEs visually.

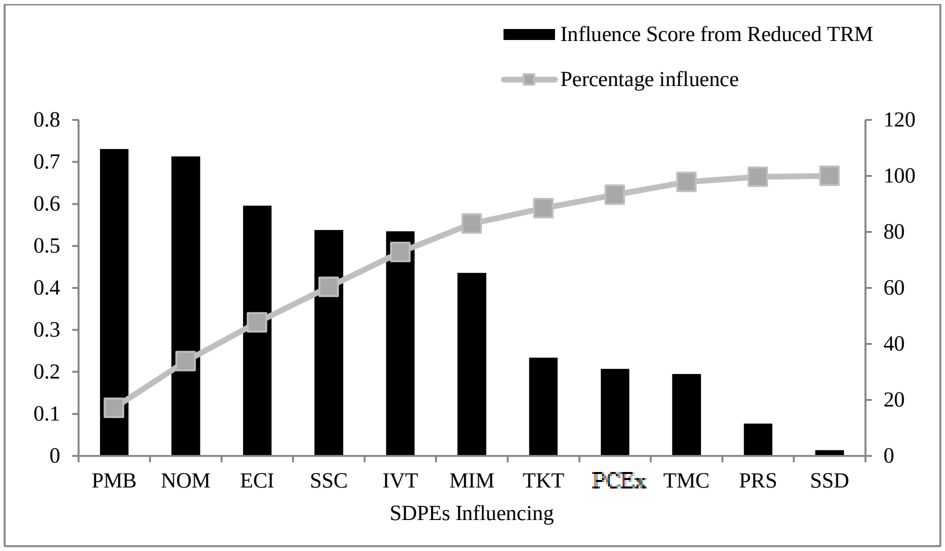


Figure 2.1.4 PARETO chart to identify group of SDPEs influencing

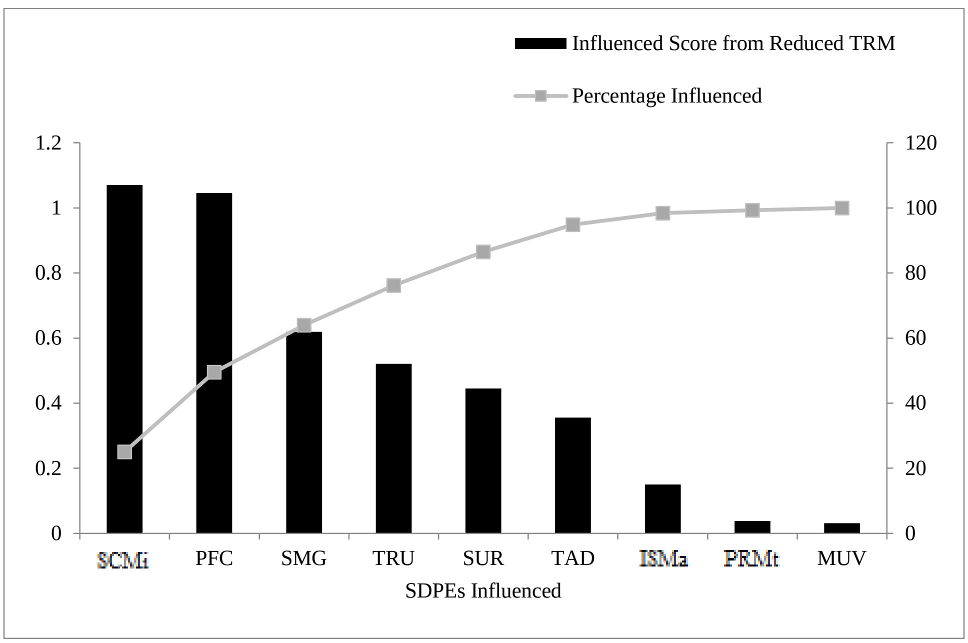


Figure 2.1.5 PARETO chart to identify group of SDPEs influenced

2.1.5.3 Establishment of interactions for each SDPE using impact relationship map

As twenty SDPEs were considered in the case situation, it was difficult to represent the interactions of all SDPEs in one Impact Relationship Map (IRM). Therefore, the IRM for each SDPE was developed based on the reduced TRM matrix to visualize its interactions. Although IRMs' for all the SDPEs were developed, only IRM for 'TMC' is shown in the Figure 2.1.6. Each SDPE influences and gets influenced by a number of SDPEs and the prominent of such SDPEs were obtained from individual PARETO chart. The details are mentioned in Table 2.1.17 and Table 2.1.18 respectively.

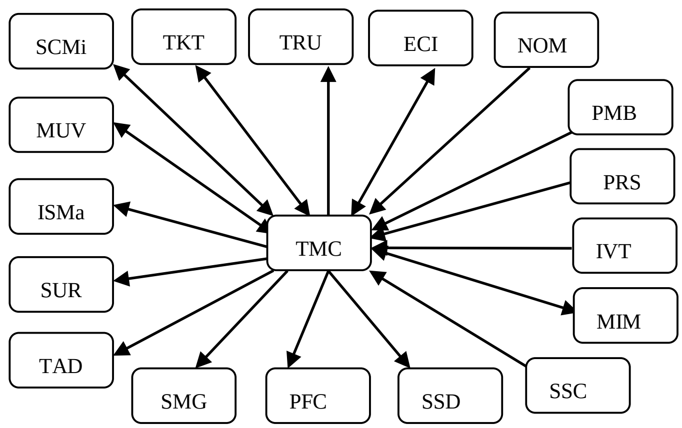


Figure 2.1.6 Impact Relationship Map of 'Top Management Commitment'

2.1.6 Sectional summary

In a manufacturing environment, the level of dependency on suppliers has grown up significantly due to the reduced vertical integration and increased focus on core competencies. This was also observed with the case company and it was evident from its emphasis on developing its extended supply chain members, dedicated department and team for managing SDPs. The company 'A' believes that the more capable and reliable their suppliers are the more they will excel in terms of supply chain performance. The case company 'A' is inclined and enthusiastic to identify and analyze the right SDPEs so that it can direct and align its efforts for successful adoption of SDPs. Thus, the proposed methodology was applied to the company 'A' and the following observations were made:

- The identified six important SDPEs were divided into cause and effect groups (see section 5.1). The SDPEs i.e. TMC, ECI and TKT were under the cause group whereas the SDPEs i.e. MUV, PFC, and SCMi were under the effect group. Thus, the case company 'A' should strategically focus on the important SDPEs under cause group since they are easily manageable. The important SDPEs under effect group are not easy to manage nonetheless they can be managed by other SDPEs.

- The company 'A' can easily control the SDPEs (i.e. PMB, NOM, ECI, SSC and IVT) of the cause group (see Figure 2.1.4). However, ECI was the most important as well as easily controllable SDPE for the company, whereas the SDPEs (i.e. SCMi, PFC, SMG and TRU) under the effect group can be easily influenced (see Figure 2.1.5). But SCMi and PFC were the most important as well as easily influenced SDPEs for the company.
- TMC and TKT (under cause group) and MUV (under effect group) were concluded as important SDPEs. For ease of presentation, IRM for TMC alone is shown in the Figure 2.1.6.

It is a well-known fact that supply chains are dynamic in nature and are subjected to different set of capacities, opportunities and constraints and so on and so forth. Bearing this in mind, the proposed methodology can be applicable to any kind of settings including number of suppliers competing in the market, available business opportunities and demographic constraints. Also, variations may come with respect to the product segments, criticality and product life cycle which have to be made uniform and tailored across all the chosen suppliers for development. This study is further extended in the later chapters to statistically validate the SDPEs by considering a sample of Indian manufacturing supply chains for complete acceptability. Therefore, the findings related to importance and analysis of interactions of SDPEs cannot be generalized. But the proposed methodology can be applied to any manufacturing company by capturing its manufacturing environment and other relevant inputs. This ends the discussion on making strategy to successfully implement the SDPs. The next section deals with the strategic analysis of SDIs.

2.2 Sectional abstract for strategic analysis of SDIs

The purpose of this section is to assist a manufacturer for determining the principal Supplier Development Impediments (SDIs) that are affecting the Supplier Development Programs (SDPs) and yield a basis for drawing the appropriate mitigation strategies. In this regard, the proposed approach starts with the application of fuzzy analytic hierarchy process and Pareto analysis to obtain the principal SDIs. Subsequently, the Interpretive Structural Modeling (ISM) and Fuzzy-Matrice d'Impacts Croisés-Multiplication Appliquée à un Classement (FMICMAC) analysis were applied on the principal SDIs to explore the root causes inducing the ineffectiveness in the SDPs. The outcomes from the proposed approach were demonstrated through a case study conducted in an Indian automotive components manufacturing company. The principal SDIs were identified, ranked, classified and structurally related for the said case company’s manufacturing environment. It was found that, lack of competent workforce, level of nascent relationship between manufacturer and suppliers and poor devolution of authority were the main SDIs that the case company has to primarily focus to make its SDPs effective. To mention about the research implications, although the study was conducted in a practical case situation, the obtained results are not indiscriminate to the other case situations. However, the proposed approach can be applied for analyzing the SDIs in any manufacturing environment once the set of SDIs relevant to that environment are carefully chosen. To mention the managerial implications, the methodology can assist a manufacturer to proactively identify the SDIs that it has to primarily focus and subsequently devise the mitigation strategies for smooth running of its SDPs. To highlight the originality, a manufacturer can make use of the identified SDIs and apply the proposed methodology to find out the main SDIs that are making the SDPs ineffective and accordingly fix the hindrances through certain mitigation strategies designed.

2.2.1 Introduction to strategic analysis of SDIs

For a country to become a competitive manufacturing hub, it must have strong supply networks established. However, often manufacturers along various Supply Chains (SCs) experience disconnected stakeholders with variegated interests pose serious setbacks rather than reinforcing their extensive support and contribution. To overcome this, manufacturers strategically steer their relationships with the suppliers by adopting various sourcing strategies that ensure stronger and cooperative supply base in the long run. There are various conditions which urge a manufacturer to strengthen its supply base. The conditions are not exhaustive; but they include the following: to meet ever increasing quality expectations (Krause and Ellram, 1997); to reduce the supply base size by focusing on critical few rather than trivial many and become competitive (Prahinski and Benton, 2004); to achieve global presence dealing with differences in operating environments (Carr and Kaynak, 2007); and/ or at least to reduce the supplier’s basic performance gaps (Carr et al., 2008); to become less vertically integrated so that a manufacturer can concentrate on core competencies and outsource the rest to the best suppliers (Routroy and Pradhan, 2013); to become adaptable and resilient to the technological uncertainties (Nagati and Rebolledo, 2013); to instigate innovation flow from the suppliers (Raafat et al., 2012); to become time and market responsive (Rotich et al., 2014); adopt and adapt to the business developments (Mohanty et al., 2014); to achieve strategic alignment (Dou et al., 2014). Because of the reasons mentioned above, SD strategy is one of the alternatives a manufacturer often takes up to develop the key strategic suppliers who are not at par in meeting its requirements and/ or expectations (Krause and Ellram (1997); Routroy and Sunil Kumar (2014); and Kumar Pradhan and Routroy (2014)). SD does not just develop the capabilities of a particular firm, but strategically develop the network of suppliers (Modi and Mabert, 2007). This strategic management of suppliers leads to improved supply networks necessary to successfully compete with other SCs (Connelly et al., 2013).

SD is not a new concept in research and it is continuously evolving in terms of methodologies and frameworks. But, in practice many companies along various SCs are still struggling with various impediments. The earlier the companies identify and overcome these impediments the better will be the chance to gain competitive advantages. On the operations field, internal and external conflicts hinder a manufacturer to get consensus on the impediments to focus. Many a time, SDIs are levied on different sides such as either on supply side/ on manufacturer side/ on both sides together and/or on external factors, leaving the manufacturers and suppliers without common opinions in deriving the action plans. Moreover, often an SDI has no single independent source, but multiple covariant sources making the situation more complex to handle. In order to address the above mentioned issues, a methodology is proposed for categorically identifying the SDIs followed by prioritizing and establishing the relationships.

The proposed methodology uses Fuzzy Analytic Hierarchy Process (FAHP) followed by Pareto analysis (to identify the principal impediments) and Interpretive Structural Modeling (ISM)-FMICMAC analysis (to establish the relationship between the SDIs). The proposed methodology is applied to an Indian automotive components manufacturing company to test its utility.

2.2.2 Literature review on SDIs

The transformations occurred in the roles of the suppliers from being just functional to strategic have urged the manufacturers to come up with competitive strategies to improve supply efficiency and effectiveness. In this regard, SD was advocated as a manufacturers' strategic effort to improve their suppliers' performance and have qualified suppliers in the supply base to attain competitive support (Leenders, 1989). With regards to the effects of an SD, Hartley and Jones (1997) highlighted that the process orientated SD effectively inculcates the suppliers to have sustainable capabilities developed for continuous improvement. Reed and Walsh (2002) found that SD is instrumental in enhancing the technological capability of the suppliers. They mentioned that it indirectly facilitates a manufacturer and its suppliers to have conducive environment for technology innovation and technology look ahead practices. Krause and Scannell (2002) classified that the suppliers' technological capability, management capability, financial capability, product development capability and manufacturer's ability to work with the key suppliers under strategic goals of SD. Lu et al. (2012) mentioned that SD enhances suppliers capabilities to implement corporate social responsibilities. Wen-li et al. (2003) also associated that emphasis of SD must be on enhancing the supplier capabilities in the long run but not just on merely achieving the performance dimensions like cost, quality and delivery speed. Sako (2004) mentioned that primarily SD is a manufacturer's effort to replicate its organizational capabilities at the suppliers and in turn have a viable organizational and governance structure established for effective reciprocation to take place in between the manufacturer and suppliers. Often the manufacturers are adopting SD strategy to reinforce their supply bases and eventually their SCs. In other words, SD is also aimed at overcoming suppliers' performance gaps and in turn improve the overall supply chain performance (Sarkar and Mohapatra, 2006). Mohanty et al. (2014) also mentioned that SD is not just beneficial for the organizations adopting it, but also for the country as a whole in terms of improved economy and employment opportunities. The abovementioned excerpts drawn from the previous research studies would certainly establish that investments made in SD should surely earn positive returns for a manufacturer as well as it suppliers. However, SD is not deeply adopted both internally and externally and are mostly limited to tier-1 suppliers of the manufacturers. This is due to the fact that SD is not being effectively transferred to the companies along the SCs making its adoption difficult and overall SD itself ineffective. (Albani and Dietz, 2006). Blonska et al. (2013) also pointed out that just by investing in SD, a manufacturer cannot completely afford to expect beneficial returns for the supplier as well as to it thorough the exchanges in between a manufacturer and supplier. Lawson et al. (2015) mentioned that firms carrying out the practices of SD and supplier involvement lack the essential discretion to synchronize their efforts. Although it was observed that SD has positive influence for both manufacturer and supplier, numerous causes affect SD returns and make SD implementation ineffective. These causes affecting the SDPs are termed as “Supplier Development Impediments” (also called as barriers, pitfalls, obstacles and hindrances). The following are the previous research studies focused on impediments and limitations to SD: Lascelles and Dale (1989) have conducted a dedicated study for examining the impediments to SD. Hartley and Jones (1997) emphasized that the firms must adopt process oriented SD in contrast to the result oriented SD for achieving lasting effect on the suppliers to continually improve on their own. Similarly, Krause et al. (1998) conducted an empirical studied and shown the contrast in between the reactive and strategic SD process and suggested that firms must pursue a strategic SD process so as reap long term benefits from the SDPs. Handfield et al. (2000) mentioned the SDIs as the pitfalls to SD and elaborately discussed about them from different specifics. Even though the researchers have widely cautioned about different SDIs that the manufacturers confront while implementing SD, there are no studies available in the literature for a manufacturer’s assistance. Specifically, a manufacturer does not have an approach to figure out the principal SDIs affecting the SDPs. Often the SDIs may originate from the supplier side or manufacturer side or both sides or from external side and/ or combinations of any or all of these. Further, studies analyzing the complex interactions among the SDIs for a manufacturer’s effective and efficient decision making are also missing. To address these research gaps, the current study is focused to identify the numerous SDIs reported in the literature. Then, a methodology is proposed for ranking, classifying and structurally relating the SDIs that can be applied in any case situation. The following sections present the critical literature review conducted in identifying the SDIs from several research works.

2.2.2.1 Supplier development impediments from supplier side

SDIs from the suppliers' side obstruct the implementation of SD because it is the supplier who has to accept and cooperate with the manufacturer's proposed initiatives (Dou et al., 2014b). Suppliers have their own culture, priorities, interests, reservations, goals and objectives to be fulfilled. Hence, the manufacturer from supplier's perspective has to identify and address the prime concerns and accordingly align their efforts meant for the supplier. The list of SDIs under supplier side category along with their brief descriptions and the contextual references are mentioned in the Table 2.2.1.

2.2.2.2 Supplier development impediments from manufacturer side

Even though it is a manufacturer who takes initiatives in developing its supply base, many a time SDIs can also originate from its side. Since these SDIs involve a manufacturer, it has to ensure that right inputs are provided to the supplier at right time; then in return, it can expect right outputs from the supplier. Many researchers in their works have mentioned a manufacturer specific SDIs affecting SD implementation. Table 2.2.2 presents a list of manufacturer's SDIs along with their brief descriptions and contextual references.

2.2.2.3 Supplier development impediments from both sides

There are certain SDIs related to both sides (i.e. supplier and manufacturer) which affect the implementation of SD. As these SDIs involve both the sides, neither a supplier nor a manufacturer alone can be held responsible. Hence, both the sides have to collectively act to mitigate these SDIs. Table 2.2.3 lists the SDIs under both sides along with their brief descriptions and contextual references.

2.2.2.4 Supplier development impediments from external side

Apart from the SDIs related to SC members, some SDIs also originate due to external factors. Although these cannot be controlled by the SC members, mitigation strategies along with necessary preparatory actions can be systematically devised. The SDIs under external side category along with their brief descriptions and contextual references are mentioned in the Table 2.2.4.

Table 2.2.1 SDIs under supplier side category

SDI	Description	Contextual References
Supplier's Reluctance and Complacence (SRCp)	Resistance and indifference shown by the supplier in implementing manufacturer's SD initiatives.	Lascelles and Dale (1990),Mortensen and Arlbjørn (2012)
Poor Supplier capacity and Flexibility (PSF)	Supplier's incapability produce manufacturer's ordered quantities and accommodate uncertainties in orders.	Modi and Mabert (2007),Mahapatra et al. (2010),Gotzamani and Theodorakioglou (2010),Han et al. (2014)
Low Preferred Manufacturer (LPM)	Low preferential status attached to the manufacturer by the supplier.	Lascelles and Dale (1990),Nollet et al. (2012),Hüttinger (2014)
Supplier's Adherence to Conventional practices (SAC)	Supplier's incapability produce manufacturer's ordered quantities and accommodate uncertainties in orders.	Gotzamani and Theodorakioglou (2010),Jain and Singh Ahuja (2012)
Lack of Business Expectancy (LBE)	Lack of faith in future business opportunities from the manufacturer.	Handfield et al. (2000),Modi and Mabert (2007),Schiele et al. (2012),Mahmood and Humphrey (2013)
Nascent Relationship (NAR)	Less time length for which supplier and manufacturer are associated with each other.	Theng Lau and Goh (2005),Handfield et al. (2006),Li et al. (2010),Thomas et al. (2011),Wagner (2011)
Lack of Competent Workforce (LCW)	Unskilled, inexperienced and incapable workforce at the supplier's side.	Gotzamani and Theodorakioglou (2010),Ellram et al. (2013),Kaplinsky (2014),Mohanty et al. (2014)
Large Potential Customer base (LPC)	Large number of potential customers the supplier serving i.e. division of services and inputs.	Handfield et al. (2006),Talluri et al. (2010),McIvor (2011),Hüttinger et al. (2012)
Less Returns on Investments (LRI)	Poor returns accrued by the supplier in serving the manufacturer.	Emiliani (2010),Ellegaard and Koch (2012),Tavani et al. (2013)
Supplier's Inability to adopt Changes (SICn)	Incapability of the supplier to implement the changes in line with manufacturer's requirements.	Leenders (1989),Modi and Mabert (2007),Mahapatra et al. (2010),Kim et al. (2010),Rajesh and Ravi (2015)
Poor Resource Capabilities (PRC)	Poor resources at supplier such as lack of technological ability, information infrastructure, financial capability…etc.	Lascelles and Dale (1989),van Donk et al. (2010)
Supplier's Supplier Condition (SSC)	Poor backward integration of the supplier.	Mahapatra et al. (2010); Prajogo et al. (2012)

Table 2.2.2 SDIs under manufacturer side category

SDI	Description	Contextual References
Inappropriate SD initiatives (ISDi)	Inappropriate SD initiatives pursued in meeting manufacturer's requirements.	Lascelles and Dale (1990),Sharma (2013)
Incorrect Selection of Supplier for development (ISSdp)	Manufacturer's inability to select right supplier for development.	Gotzamani and Theodorakioglou (2010),Punniyamoorthy et al. (2011)
Poor Support Extended to the supplier (PSEx)	Manufacturer's poor support to its supplier in implementing SD initiatives.	Emiliani (2003),Handfield et al. (2006),Carr and Kaynak (2007),Talluri et al. (2010)
Longer Outstanding Payables (LOP)	Longer times taken by the manufacturer in paying back the supplier for its inputs and services.	Emiliani (2003),Srinivasan et al. (2011),Dries et al. (2014)
Poor Supplier Integration (PSIt)	Poor comprehension of a supplier and involvement at right stages of value addition process.	Mahapatra et al. (2010),Gotzamani and Theodorakioglou (2010),Talluri et al. (2010),Danese (2013)
Poor Supplier Motivation mechanisms (PSM)	Lack of mechanisms designed motivating supplier participation and contribution.	Mahapatra et al. (2010),Gotzamani and Theodorakioglou (2010),Wang (2010),Mortensen and Arlbjørn (2012)
Poor supplier Evaluation and Feedback systems related to SD (PEF)	Lack of available systems for evaluating the supplier and to collect feedback.	Lascelles and Dale (1990),Modi and Mabert (2007), Kumar et al. (2011),Prajogo et al. (2012)
Unclear or Complex Targets set (UCT)	Unclear, complex and expensive targets set to the supplier.	Stjernström and Bengtsson (2004),Sarkis (2012),Mohanty et al. (2014)
Less strategic importance to purchasing (LSI)	Still purchasing is treated as functional rather than strategic.	Mortensen and Arlbjørn (2012),Masi et al. (2013),Paik (2014)
Manufacturer's Project Completion exercise (MPC)	Ability of a supplier to finish the project on time and fulfilling all the contracted requirements.	Theng Lau and Goh (2005),Singh et al. (2012),Routroy and Sunil Kumar (2014),Routroy and Pradhan (2014)

Table 2.2.3 SDIs under both sides category

SDI	Description	Contextual References
Poor Turnout Time (PTT)	Unavailability of the manufacturer or supplier to respond for each other at and in right time	Mahapatra et al. (2010),Kim et al. (2010),Thakkar et al. (2013),Zhou et al. (2014)
Lack of Mutual Trust (LMT)	Lack of belief or fear of opportunistic attitude from each other in carrying out business transactions	Mahapatra et al. (2010),Kim et al. (2010),Gotzamani and Theodorakioglou (2010),Mortensen and Arlbjørn (2012)
Poor Communication and Feedback systems (PCF)	Lack of organized communication systems for conveying mutual interests and confirmations.	Stjernström and Bengtsson (2004),Modi and Mabert (2007),Humphreys et al. (2011),Mortensen and Arlbjørn (2012),Thakkar et al. (2013)
Lack of Adaptability (LAT)	Inability to cope up with business process improvements and transformations.	Mahapatra et al. (2010),Kumar Pradhan and Routroy (2014),Pal et al. (2014)
Mismatch in Goals and Objectives (MGO)	Difference in interests and priorities of the parties.	Mortensen and Arlbjørn (2012),Praharsi et al. (2013),Mahmood and Humphrey (2013),Zhou et al. (2014)
Lack of Top management Commitment (LTC)	Poor commitment and support from the top managements.	Handfield et al. (2006),Svensson et al. (2010),Gotzamani and Theodorakioglou (2010)
Poor Profit and Risk sharing mechanisms (PPR)	Poor mechanisms laid out for profit and risk sharing.	Mahapatra et al. (2010),Gotzamani and Theodorakioglou (2010),Kumar Pradhan and Routroy (2014)
Poor Devolution of Authority (PDA)	Poor employee authorization and empowerment to make decisions and take necessary actions.	Heilmann et al. (2011),Lockström and Lei (2013),Kumar Pradhan and Routroy (2014)
Poor Technology and Knowledge transfer (PTK)	Poor sharing of technology and knowledge with each other.	Mahapatra et al. (2010),Thomas et al. (2011),Krause and Ellram (2014),Zhou et al. (2014)
Poor Conflict Management (PCM)	No clearly laid out resolutions for solving conflicts between the parties.	Emiliani (2003),Mahapatra et al. (2010),Praharsi et al. (2013)
Lack of Total cost Perspective (LTP)	No total cost considerations while carrying out business transactions but often concerned with pricing.	Stjernström and Bengtsson (2004),Dogan and Aydin (2011),Kumar Pradhan and Routroy (2014)
Lack of Coordination (LCD)	No synchronization in execution of planned activities.	Mahapatra et al. (2010),Heilmann et al. (2011),Thakkar et al. (2013),Kumar Pradhan and Routroy (2014)
Lack of Compatibility (LCT)	Difference in environmental setups, constraints, opportunities, organizational structures and supply chain configurations.	Mahapatra et al. (2010),Praharsi et al. (2013),Lockström and Lei (2013)
Employee Attrition Rate (EAR)	Large number of employees leaving the organizations.	Heilmann et al. (2011),Phillips et al. (2012)

Table 2.2.4 SDIs under external side category

SDI	Description	Contextual References
Economy Fluctuations (EFL)	Change in the economic conditions of the nations in which organizations are operating.	Mahapatra et al. (2010),Kumar et al. (2011),Friedl and Wagner (2012),Monczka and Petersen (2012),Ruhrmann et al. (2014)
Political Pressures and Uncertainties (PPU)	Pressure from politicians in making decisions besides with change in the scenarios.	Pieter van Donk et al. (2010),Monczka and Petersen (2012),Morris et al. (2012),Thakkar et al. (2013)
Unavailability of Natural Resources (UNR)	Lack of natural resources necessary for running the organizations.	Mahapatra et al. (2010),Thakkar et al. (2013),Arráiz et al. (2013)
Increased Competition (INC)	Increase in the level of competition from other manufacturers.	Stjernström and Bengtsson (2004),Nagati and Rebolledo (2013),Mahmood and Humphrey (2013)
Rapid Changes in Technology (RCT)	Rapid technological changes like information technology, logistics and automation.	Mahapatra et al. (2010),Thakkar et al. (2013),Nagati and Rebolledo (2013),Sucky and Durst (2013),Zhao et al. (2014)
Changing Customer Expectations (CCE)	Drift in customers' interests and expectations from the services and products.	Krause and Ellram (1997),Mahapatra et al. (2010),Thakkar et al. (2013),Routroy and Pradhan (2014)
Work Culture (WCL)	Differences in work culture create challenge to organizations in getting their works done.	Mahapatra et al. (2010),Gotzamani and Theodorakioglou (2010),Schiele (2010),Mohanty et al. (2014),Pal et al. (2014)
Environmental Disasters (EDI)	Environmental calamities disrupting the functions of the organizations.	Trkman and McCormack (2009),Kumar et al. (2012)
Government’s changing Rules and Regulations (GRR)	Changes in government's policies, rules, regulations and standards force companies to inevitably act.	Mahapatra et al. (2010),Monczka and Petersen (2012),Thakkar et al. (2013),Dries et al. (2014)
Power and other Basic Supplies (PBS)	Poor and expensive supply of power, land, roads and other necessary facilities for running the organizations.	Trkman and McCormack (2009),Kihara and Ngugi (2013)
Industry disruptions (IND)	Comedown in other industries often have impact on the abilities of the organizations.	Kumar et al. (2011),Thakkar et al. (2013),Lorentz et al. (2013)
Unethical practices by competitors (UPC)	Fraud and other unethical means adopted by the competitors in winning orders.	Ehrgott et al. (2013),Akamp and Müller (2013),Mahmood and Humphrey (2013)
Underdeveloped region of operation (URO)	Poorly facilities and non IT enabled regions often throw serious challenges to operate.	Wu et al. (2010),Dekker et al. (2013)
Poor connectivity between supplier and manufacturer (PCO)	Lack of transportation facilities available for organizations to operate.	Trkman and McCormack (2009)

The SDIs listed and described in the above sections form the generic list of SDIs under each category which prevail almost in all SD environments. However, the lists are not exhaustive and may include/ exclude some SDIs in a specific environment. Thus, these lists of SDIs must be subjected to a series of screening tests to obtain the relevant (whether or not the SDIs are pertinent to the manufacturing environment in which SD is implemented), distinctive (to eliminate those SDIs which are repetitive), grossly insignificant (to safely eliminate those which are not actively contributing) and unidirectional (to make sure that the considered SDIs are in one direction, either positive or negative) SDIs under each category (Routroy and Sunil Kumar, 2014). These screened SDIs are further processed and analyzed by applying the methodology detailed in the next section.

2.2.3 Methodology to address principal supplier development impediments

Often the SDIs are sprouted out from various sources or their sub-sources; but rarely, these are explored or allowed to be exposed due to various reasons. The main reasons include: lack of consensus and conflicts among the employees in accepting the responsibilities; failure to broadly choose and address the right SDIs; high level of complexity involved in understanding the relationships between the SDIs; and finally no formal process to systematically respond to thHe SDIs with proper planning and execution. To facilitate the manufacturers in addressing the above mentioned limitations, the following proposed methodology uses FAHP, Pareto analysis and ISM-FMICMAC analysis. The step by step procedure of the methodology along with the flowchart (see Figure 2.2.1) is detailed below.

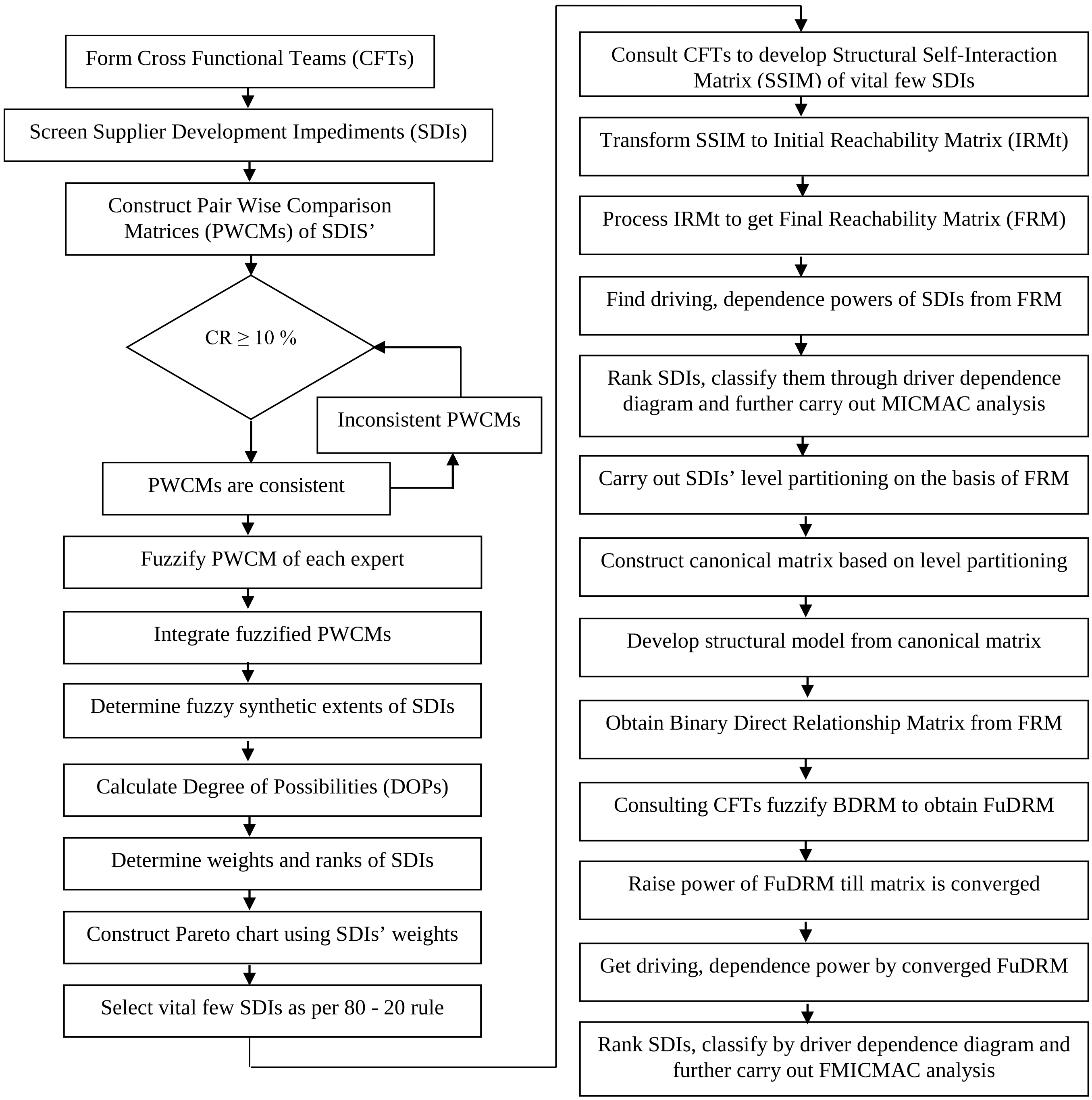


Figure 2.2.1 Flowchart for addressing the principal SDIs

2.2.3.1 Fuzzy analytic hierarchy process

The Analytic Hierarchy Process (AHP) proposed by Saaty (1980) is one the prominent decision making techniques used by the researchers to find out the relative importance of multiple criteria

(Hsiao and Ko, 2013). AHP is often integrated with fuzzy set theory and is termed as Fuzzy AHP (FAHP) to deal with the imprecision and uncertainty in the pair wise comparisons made along the criteria (Shaw et al., 2012). FAHP has the ability to capture the inherent uncertainty and imprecision associated in mapping a decision maker's perceptions to crisp values (Routroy and Pradhan, 2013b). In applying the FAHP, the Triangular Fuzzy Numbers (TFNs) are preferred for capturing the imprecise qualitative expressions along the criteria owing to their computational simplicity (Shaw et al., 2012). Moreover, the advantage of FAHP is that, it is accurate in the ratio scale measurements and can be combined with many other decision support tools (Millet and Wedley, 2002). Since, here the requirement was also to find out the relative importance of SDI categories as well as SDIs under each category, the AHP method was chosen in the current context. As the relative comparisons of SDIs can also be imprecise and uncertain in nature, the FAHP using TFNs was believed to be more appropriate in the current context. Further, FAHP is also found suitable as it was easy to combine with ISM-FMICMAC for subsequent analysis of SDIs.

The step by step procedure of FAHP and Pareto analysis used in this study is detailed below,

Step 1. Form the Cross Functional Teams (CFTs) and screen the SDIs to obtain relevant, irredundant, grossly significant and unidirectional SDIs under each category (see section 2).

Step 2. Construct pair wise comparisons of SDIs (SDI categories as well as SDIs under each category) using a scale 1 to 9 (see Table 2.2.5). The comparisons are carried out reflecting the domination of one SDI over the other.

Step 3. Check the consistency in pairwise comparisons of SDIs. To do so, normalize the column wise values by dividing each entry by the sum of all entries. Then sum each row of the normalized values and take the average. This gives out Principal Vector (PV). The judgments in the check for consistency is as follows:

Let the Pair Wise Comparison Matrix (PWCM) be denoted M1 and principal vector be denoted M2.Then define M3 = M1*M2 and M4 = M3/M2.

λmax = average of the attributes of M4 and

Consistency Index (CI) = (λmax - N)/ (N - 1)

Consistency Ratio (CR) = CI/RI corresponding to N where RI: Random Consistency Index (see Table 2.2.6) and N: Number of attributes. If CR is less than 10%, judgments are considered consistent. And if CR is greater than 10%, the quality of judgments should be improved to have CR less than or equal to 10%.

Table 2.2.5 Scale for pairwise comparisons (Saaty, 1980)

Importance measure	Definition
1	Equally important
2	Equally to moderately more important
3	Moderately more important
4	Moderate to strongly more important
5	Strongly more important
6	Strong to very strongly more important
7	Very strongly more important
8	Very to extremely strongly more important
9	Extremely more important

Table 2.2.6 Random Index values (Saaty, 2000)

Number of attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Random Index	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Step 4. After consistency test is passed, matrix from each expert is fuzzified (Lee, 2009) as mentioned Table 2.2.7. For an expert t, the fuzzy pair wise comparison of SDI 'i' and SDI 'j' is denoted by $(P_{ijt}, Q_{ijt}, R_{ijt})$.

Step 5. An integrated triangular fuzzy number(D_{ij}) for SDI 'i' and SDI 'j' is obtained by combining the judgments of all the experts. The geometric mean method is used to form single integrated Fuzzy Pair Wise Comparison Matrix (FPWCM). The triangular fuzzy number is denoted by ($b_{ij}^{-}, b_{ij}, b_{ij}^{+}$) and it is calculated as given below (Lee, Kang, Hsu, and Hung, 2009).

$$b_{ij}^{-} = [\prod_{t=1}^{s} P_{ijt}]^{(1\,/\,t)} \quad \text{Where t= 1, 2… s}$$

$$b_{ij} = [\prod_{t=1}^{s} Q_{ijt}]^{(1\,/\,t)} \quad \text{Where t= 1, 2… s}$$

$$b_{ij}^{+} = [\prod_{t=1}^{s} R_{ijt}]^{(1\,/\,t)} \quad \text{Where t= 1, 2… s}$$

Table 2.2.7 Membership functions of the fuzzy numbers (Source: Lee 2009)

Crisp judgement of the pairwise matrix	Triangular Fuzzy Number
1	(1,1,2)
2	(x-1, x, x+1) for x = 2,3,…,8
9	(8,9,9)
1/1	(2^{-1},1^{-1},1^{-1})
1/x	($(x+1)^{-1}$,x^{-1},$(x-1)^{-1}$) for x = 2,3,…,8
1/9	(9^{-1},9^{-1},8^{-1})

Step 6. The integrated FPWCM of SDIs is defuzzified as mentioned below (Kwong and Bai, 2003) in order to check the consistency (as discussed in step 3). If it is inconsistent then go to Step 3 otherwise go to step 8.

$$b_{ij} = (b_{ij}^{-} + 4b_{ij} + b_{ij}^{+})/6$$

Step 7. The fuzzy synthetic extent (F_i) (Chang (1996); Lee (2009); Lee, Kang, Hsu, et al. (2009); and Lee, Kang, and Chang (2009)) for each SDI is calculated as mentioned below.

$$F_i = \{m_i^-, m_i, m_i^+\} = \{\frac{\sum_{j=1}^{n} b_{ij}^-}{\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}^+}, \frac{\sum_{j=1}^{n} b_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}^+}, \frac{\sum_{j=1}^{n} b_{ij}^+}{\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}^-}\}$$

Step 8. Fuzzy Synthetic Extent (FSE) of each SDI is compared with the FSEs' of the rest of the SDIs and a value called Degree Of Possibilities (DOPs)$\mu(F_i)$ (Chang, (1996) and Zhu et al., (1999)) is calculated as mentioned below.

$$\mu(F_2 \geq F_1) = \begin{cases} 1, & m_2 \geq m_1 \\ 0, & m_1^- \geq m_2^+ \\ \dfrac{[\, m_1^- - m_2^+]}{[(m_2 - m_2^+) - (m_1 - m_1^-)]} & otherwise \end{cases}$$

Step 9. The minimum value among the Degree of Possibilities (DOPs) $\mu(F_i)$ for SDI i will be the weight ascribed for the respective SDI.

Note: Thus, by following the procedural steps 1-9 the categorical weights of SDIs as well as weights of SDIs under each category can be obtained.

Step 10. Multiply the categorical weights of SDIs with the weights of SDIs under respective category to obtain the normalized weights of SDIs.

Step 11. Apply Pareto analysis on the normalized weights of SDIs to select the significantly affecting SDIs. These significant SDIs are further analyzed by applying ISM-FMICMAC Analysis.

2.2.3.2 ISM-FMICMAC analysis

ISM methodology has the ability to draw the order and direction of relationships among factors/ barriers/ impediments of a complex system (Sage, 1977). ISM is a qualitative tool used by a number of researchers in various environments to develop a mind map of factors influencing the system under study on the basis of experts' opinions. It is capable of providing the driving and dependence powers of SDIs which are essential for a decision maker to classify the SDIs and to focus on the right SDIs.

Step-1 Develop Structural Self-Interaction Matrix (SSIM) by drawing contextual relationships among the principal SDIs obtained from the previous section 3.1. These contextual relationships show the way they are related to each other in the manufacturing SC environment where the study is carried out. They are created considering the experts' judgment. Four symbols (A: SDI 'j' leads to SDI 'i'; V: SDI 'i' leads to SDI 'j'; X: SDI 'i' leads to SDI 'j' and SDI 'j' leads to SDI 'i' and O: No relationship between SDI 'i' and SDI 'j') are used for the type of the relation that exists between the SDIs ('i' and 'j').

Step-2 Develop the Initial Reachability Matrix (IRMt) by converting SSIM into a binary matrix, substituting V, A, X and O by 1 and 0. The substitution by 1's and 0's are as per the following rules:

- If the (i, j) entry in the SSIM is V, then the (i, j) entry in the IRMt becomes 1 and the (j, i) entry becomes 0.
- If the (i, j) entry in the SSIM is A, then the (i, j) entry in the IRMt becomes 0 and the (j, i) entry becomes 1.
- If the (i, j) entry in the SSIM is X, then the (i, j) entry in the IRMt becomes 1 and the (j, i) entry also becomes 1.
- If the (i, j) entry in the SSIM is O, then the (i, j) entry in the IRMt becomes 0 and the (j, i) entry also becomes 0.

Step-3 Develop the Final Reachability Matrix (FRM) from IRMt considering transitivity among the contextual relations of SDIs. Transitivity in the relationship is determined as follows: if SDI "i" is related to SDI 'j' and SDI 'j' is related to SDI 'k', then SDI 'i' is related to SDI 'k'. Then the (i, k) entry in the FRM becomes 1*. Driving and dependence power of each SDI is determined by taking summation of the elements along the rows and columns of FRM respectively. The SDIs are ranked on the basis of driving and dependence powers.

Step-4 Carry out the level partitioning of SDIs by developing the reachability and antecedent sets for each SDI on the basis of FRM. The reachability set of a SDI contains the SDI itself and other SDIs which it may reach. Whereas, the antecedent set of a SDI contains the SDI itself and other SDIs which may reach it. The SDIs for which the reachability and intersection sets are same occupy the top-level in the ISM hierarchy. The top-level SDIs are separated out from the initial set of SDIs and then the process is repeated until all the SDIs are assigned to a level.

Step-5 From the obtained level partitions a lower triangular matrix or canonical matrix is developed. It is just another form of FRM in which SDIs are positioned and clustered according to the level of partition. This canonical matrix forms the basis for developing a directed graph called as digraph. If there is a relationship between SDI 'i' and SDI 'j', this is shown by an arrow which points from SDI 'i' to SDI 'j'.

Step-6 The structural model of SDIs is generated by eliminating the transitivity links in the diagraph (obtained in the step-6) and considering the level partitions (in step-5) and FRM (in step-4).

Step-7 The structural model of SDIs developed in Step-7 is reviewed for conceptual accuracy. If it is not conceptually accurate, then go to Step-1.

Step-8 In the IRMt (see step-4), replace all the diagonal elements along with the transitive relationships with 0's to obtain a Binary Direct Relationship Matrix (BDRM).

Step-9 Approaching the same members of CFTs (see step-1), judgments regarding the relationships between SDIs in the BDRM should be recollected using the scale mentioned in the Table 2.2.8 to obtain Fuzzy Direct Relationship Matrix (FuDRM).

Step-10 The FuDRM's power is raised by fuzzy matrix multiplication (rule: $C = \max_k \{\min (a_{ik}, b_{kj})\}$ where $A = [a_{ik}]$, $B = [b_{kj}]$) till it is converged (Kandasamy et al., 2007). The convergence point can be determined where the driving and dependence powers of SDIs are stabilized or cyclic in their variation with certain periodicity.

Step-11 Based on the new driving and dependence powers obtained from the final converged matrix, driver dependence diagram is to be plotted (with dependence power along the X-axis and driving power along the Y-axis) and SDIs are to be classified in to four groups (i.e. autonomous having lower dependence and driver power, dependent having higher dependence and lower driver power, linkage having higher dependence and driver power and independent having lower dependence and higher driving power).

Table 2.2.8 Possible Relationship Strength between SDPIEs

Dominance of Interaction	**No.**	**Very Low**	**Low**	**Medium**	**High**	**Very High**	**Full**
Grade	N	NL	L	M	H	VH	F
Value on the Scale	0	0.1	0.3	0.5	0.7	0.9	1

2.2.4 Case study

In order to check the utility of the proposed methodology, an Indian automotive components manufacturing company was approached. To maintain the confidentiality and to protect the interests of the company, from henceforth in the discussion the case company is denoted by ‘Z’. The company ‘Z’ is well known for its long business history, high quality supplies, flexibility and long term relationships established with many reputed automobile companies in India and abroad. The strategies practiced by the company ‘Z’ in meeting its customers’ requirements are unique in the industry and are well conceived and developed over a period of time. However, much of the risks and uncertainties in serving its customers were rooted on its supply side. This was uncovered only when the manufacturing systems inside the company were made efficient by adopting lean philosophy and other management models. Since, the lean transformation was an internal exercise, the company could achieve a reasonable level of efficiency at ease. But, it was quite a challenge for it to take along the suppliers with it especially the critical and strategic suppliers. To overcome these issues the company ‘Z’ often adopt mixed sourcing strategies to make its supply base efficient enough in meeting its performance requirements. As one of the sourcing alternative, SD is deployed across critical and strategic suppliers. Initial response of the company experts was that they treat their suppliers well and their suppliers were also satisfied with the system. Then as per the methodology detailed in the section 3.1, CFTs were formed with experts drawn mainly from purchasing, quality, production planning and control, research and development, marketing and logistics departments including skilled and experienced bottom-line workforce. The advantage with the case company was, it dedicated some amount of time (every weekend day), space and infrastructure (named as Incubation Centre) for training its human resources, conducting feedback collection sessions and for business presentations. So, it was easy to bring the cross functional department's personnel on to the common platform. Totally 6 CFTs were formed by balancing the number and experience. With these CFTs, the categorically identified SDIs presented in the section 2 (see Tables 2.2.1-2.2.4) were shared and discussed. After conducting the screening tests, 48 SDIs out of 58 were considered for the study. The objectives of the proposed methodology were discussed with the CFTs and they accepted to extend their cooperation. They agreed that this method would bring consensus in their thinking and the outcomes may be helpful for the company to identify the areas it has to concentrate in future. At this juncture, the Pair Wise Comparison Matrices (PWCMs) were constructed along the categories of SDIs as well as SDIs under each category and CFTs were sought to express their opinion (see step 2 of section 3.1, Table 2.2.9 and Table 2.2.10) in order to determine their respective weights. Firstly, the weights of SDI categories were determined followed by the weights of SDI under each category such that if any SDI category is not relevant or insignificant with respect to the company Z's environment, then SDI weights under that particular SDI category need not be determined. In the current study as per the case company's manufacturing environment, external side SDI category was considered relatively insignificant.

The PWCMs constructed under the chosen SDI categories were checked for consistency as per step 3 of section 3.1; accordingly whichever PWCM was not consistent, the corresponding CFT's response was sought repeatedly till consistency was achieved. Once consistent PWCMs were constructed, they were fuzzified, integrated and defuzzified (see steps 4-6 of section 3.1). From defuzzified matrices, FSE of each SDI followed by DOPs were determined (see steps 7 and 8 of section 3.1). On the basis of DOPs as per step 9, weights of SDI categories as well as SDIs under each category were determined. Then as per the step 10, weights of SDI categories were multiplied with the weights of SDIs under corresponding category to obtain normalized weights of SDIs (see

Table 2.2.11). Taking the whole list of normalized weights of SDIs from all categories, Pareto analysis was conducted to select vital few that are significantly affecting SD implementation (see Figure 2.2.2). In order to gain deeper understanding of SDIs and derive action plans, SDIs were further processed by applying ISM-FMICMAC analysis. Following the steps mentioned in the section 3.2, as per step 1, SSIM of SDIs was constructed (see Table 2.2.12).

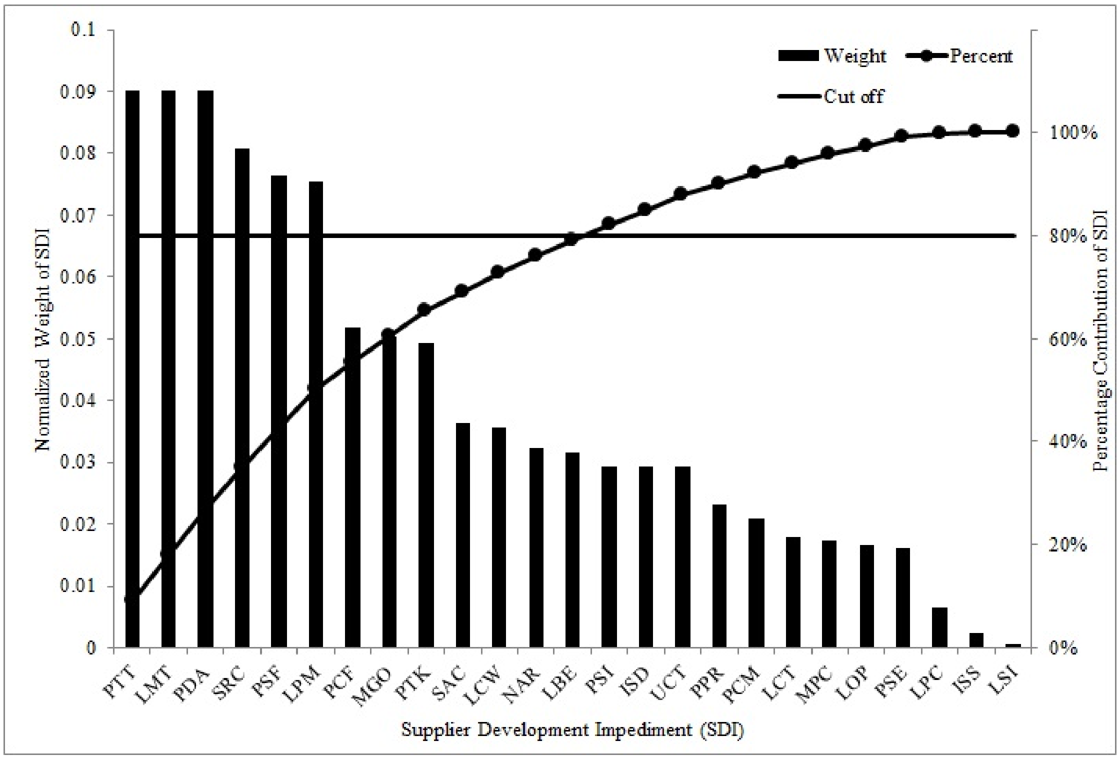


Figure 2.2.2 Pareto chart to select Principal SDIs

According to step 2, SSIM was transformed in to IRMt (see Table 2.2.13) and on the basis of this, FRM of SDIs was developed (see Table 2.2.14) as per step 3. Then from FRM, the SDIs were partitioned across different levels (see Table 2.2.15) according to step 4. Following the step 5, canonical matrix was developed and diagraph was developed on the basis of it. By eliminating transitive links from the digraph, ISM structural model of SDIs was developed as per step 6 (see Figure 2.2.3). As stated in the step 7, conceptual accuracy of the developed model was checked by consulting CFTs and it was found satisfactory. According to step 8, BDRM of SDIs was formed and it was fuzzified to obtain FuDRM as per step 9 (see Table 2.2.16). Then with respect to step 10, the power of FuDRM was raised continuously till it is converged (see Table 2.2.17 and Figure 2.2.4). Finally, as per step 11 the driver dependence diagram was constructed on the basis of driving and dependence powers obtained from the final converged matrix (see Figure 2.2.5). The significance of the obtained results along with their implications are discussed in detail in the next section.

2.2.5 Results and discussions

As per the proposed methodology, weights of the identified SDI categories were determined using FAHP. The obtained weights were 0.375, 0.141, 0.484 and 0 for supplier, manufacturer, both sides and external side respectively. It is evident from the weights that rather than external environment, the other categories (i.e. supplier, manufacturer and both sides) were significant for the company 'Z'.

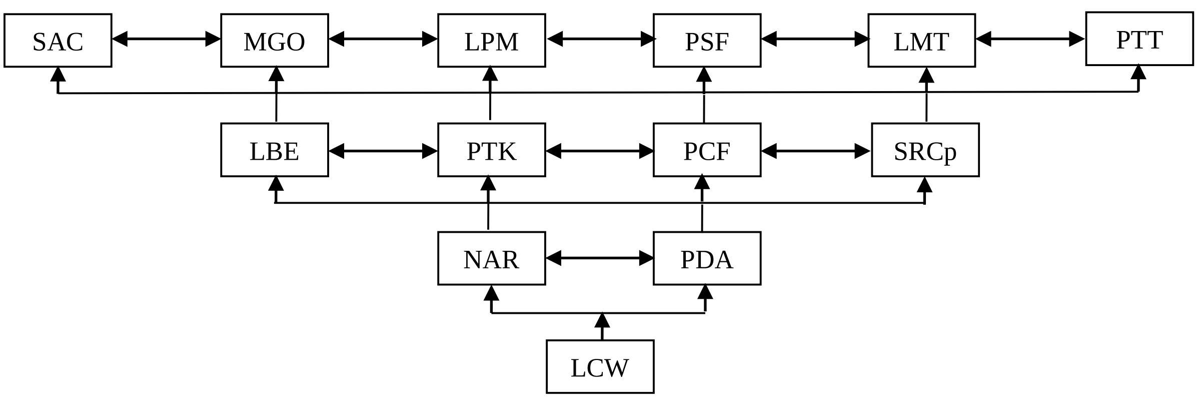


Figure 2.2.3 ISM model of Principal SDIs

At this stage, after eliminating the SDIs under external side SDI category, there were altogether 39 SDIs. Further, the weights of SDIs were determined and multiplied by their respective category weights to obtain the normalized weights. At this step, the 39 SDIs were reduced to 25 SDIs by eliminating the zero weighted SDIs (see Table 2.2.13). Considering the weights of 25 SDIs, Pareto analysis was conducted to extract the principal SDIs. From 25 SDIs, 13 SDIs were chosen as principal SDIs from all the given categories. To explore and study the relationship between these 13 principal SDIs and further draw an action plan for the company 'Z', the ISM-FMICMAC analysis was carried out. By applying ISM, a structural model of SDIs was developed (see Figure 2.2.3). From the Figure 2.2.3, it can be observed that SDIs were positioned with respect to the driving and dependence powers of SDIs as well as the partitioned levels. SDIs positioned in the lower levels indicate high driving power while those positioned in the top most levels indicate high dependence power. Thus, from the ISM model it can be inferred that low competent workforce, nascent relationship and poor devolution of authority (located at lower levels) were the most significant SDIs driving all other SDIs. Hence, the company 'Z' has to design and develop the action plans mainly keeping these SDIs in mind. On the basis of driving powers of SDIs they were ranked as, LCW > NAR > PTK > SAC > LBE > PDA > SRCp > PCF > MGO > LMT > PSF > LPM > PTT. While on the basis of dependence powers, the SDIs were ranked as, PTT > LMT > LPM > MGO > PSF > PCF > SRCp > PTK > SAC > PDA > LBE > LCW > NAR (see Table 2.2.17). In order to get more comprehensive view of SDIs, they were further classified with the help of driver dependence diagram.

2.2.5.1 Classification of SDIs

The classification of SDIs is primarily carried out on the basis of driving and dependence powers extracted from the final converged matrix (see Table 2.2.17). This matrix is obtained by raising the power of FuDRM through fuzzy matrix multiplication. In this case, the final converged matrix was obtained by raising the power of FuDRM by four times (see Figure 2.2.4). At last the driving and dependence powers of SDIs were calculated from the final converged matrix. Using these driving and dependence powers, the SDIs were plotted on the driver dependence diagram.

Depending upon the intensity of powers the driver dependence diagram was divided into four quadrants: Driver, Autonomous, Dependent and Linkage quadrants (see Figure 2.2.5). The significance of these quadrants and the nature of SDIs grouped under these are discussed as follows,

Driver quadrant - (High driving power, Low dependence power)

Those SDIs which are clustered in this quadrant seriously affect SD implementation and growth, as these are key SDIs in affecting the whole system by and large. LCW, NAR and PDA are grouped under this quadrant and this is confirmed even through the structural model developed through ISM. It can be seen that those SDIs which are relatively broad in overcoming are clustered in this group.

Autonomous quadrant - (Low driving power, Low dependence power)

Those SDIs fall in this cluster are characterized as relatively less connected to the system under study. These SDIs neither influence nor influenced by other SDIs with respect to the hindrance posed in the SD implementation. Thus, these SDIs can be treated as not so important impediments. In the current study there are no SDIs falling in this group i.e. all the considered SDIs are strongly influential.

Dependent quadrant - (Low driving power, High dependence power)

Since these SDIs are highly dependent in nature, it is mandatory to identify the SDIs on which these are dependent on so as to overcome them and accordingly direct the resources. In the current study, SDIs namely, PSF, MGO, LMT, LPM and PTT had fallen in this cluster.

Linkage quadrant - (High driving power, High dependence power)

SDIs falling in this quadrant can be treated as unstable as they have feedback effect on themselves. Any attempt to change these will affect the SD implementation process. However, these SDIs cannot be neglected but their statuses have to be closely monitored in order to make right decisions. The SDIs namely, PTK, SAC, SRCp, PCF and LBE were grouped under this cluster.

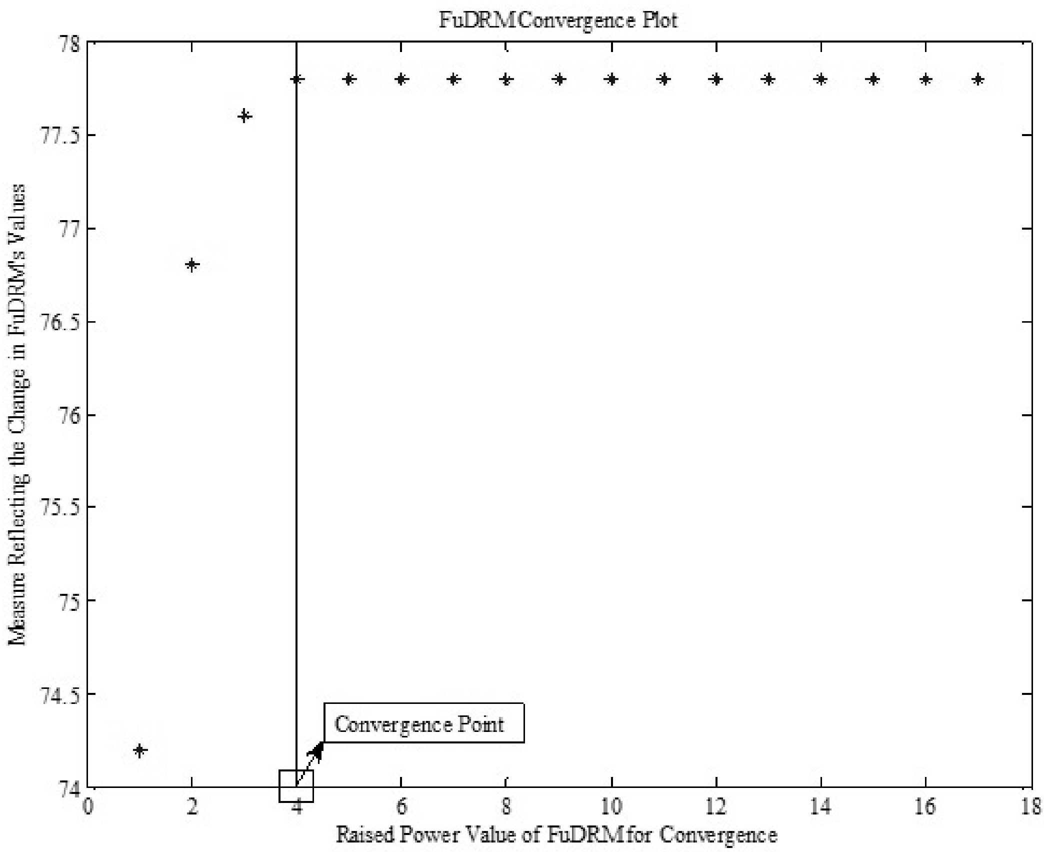


Figure 2.2.4 Convergence plot of Fuzzy Direct Relationship Matrix

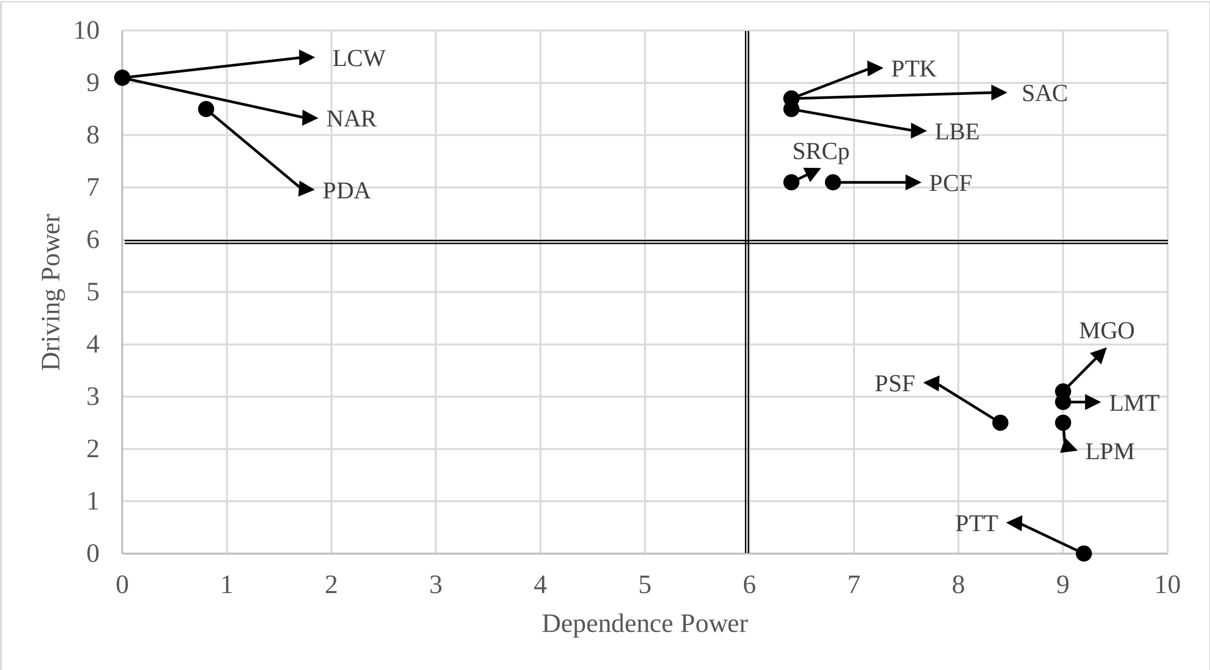


Figure 2.2.5 FMICMAC Driver Dependence Diagram of Principal SDIs

Table 2.2.9 Pair Wise Comparison Matrices of SDI Categories

	BS	SS	MS	ES
BS	1	2	3	4
SS	0.5	1	2	3
MS	0.333	0.5	1	1
ES	0.25	0.333	1	1
BS: Both Sides; SS: Supplier Side; MS: Manufacturer Side; ES: External Side				

Table 2.2.10 Pair Wise Comparison Matrix of Supplier Side Category SDIs

	SRCp	SAC	LCW	LPM	NAR	LPC	SSC	PCF	PRC	LBE	LRI	SICn
SRCp	1	4	2	1	5	2	1	2	5	5	4	2
SAC	0.25	1	2	1	5	2	1	1	5	5	4	2
LCW	0.5	0.5	1	1	5	2	1	1	5	5	4	2
LPM	1	1	1	1	1	1	1	2	2	3	3	3
NAR	0.2	0.2	0.2	1	1	1	1	2	2	3	3	3
LPC	0.5	0.5	0.5	1	1	1	1	2	2	3	3	3
SSC	1	1	1	1	1	1	1	2	2	3	3	3
PCF	0.5	1	1	0.5	0.5	0.5	0.5	1	1	2	2	2
PRC	0.2	0.2	0.2	0.5	0.5	0.5	0.5	1	1	2	2	2
LBE	0.2	0.2	0.2	0.333	0.333	0.333	0.333	0.5	0.5	1	1	1
LRI	0.25	0.25	0.25	0.333	0.333	0.333	0.333	0.5	0.5	1	1	1
SICn	0.5	0.5	0.5	0.333	0.333	0.333	0.333	0.5	0.5	1	1	1

Table 2.2.11 Weights of SDI categories and the SDIs under respective category

Supplier Side Category				Manufacturer Side Category				Both Side Category			
SDI	WSDI	WSDIC	NWSDI	SDI	WSDI	WSDIC	NWSDI	SDI	WSDI	WSDIC	NWSDI
SRCp	0.215	0.375	0.080625	PSIt	0.208	0.141	0.029328	PTT	0.186	0.484	0.090024
PSF	0.204	0.375	0.0765	ISDi	0.208	0.141	0.029328	LMT	0.186	0.484	0.090024
LPM	0.201	0.375	0.075375	UCT	0.208	0.141	0.029328	PDA	0.186	0.484	0.090024
SAC	0.097	0.375	0.036375	MPC	0.123	0.141	0.017343	PCF	0.107	0.484	0.051788
LBE	0.084	0.375	0.0315	LOP	0.118	0.141	0.016638	MGO	0.104	0.484	0.050336
NAR	0.086	0.375	0.03225	PSEx	0.114	0.141	0.016074	PTK	0.102	0.484	0.049368
LCW	0.095	0.375	0.035625	ISSdp	0.017	0.141	0.002397	PPR	0.048	0.484	0.023232
LPC	0.017	0.375	0.006375	LSI	0.004	0.141	0.000564	PCM	0.043	0.484	0.020812
LRI	0	0.375	0	PSM	0	0.141	0	LCT	0.037	0.484	0.017908
SICn	0	0.375	0	PEF	0	0.141	0	LTP	0	0.484	0
PRC	0	0.375	0					LCD	0	0.484	0
SSC	0	0.375	0					LAT	0	0.484	0
								LTC	0	0.484	0
								EAR	0	0.484	0
Supplier Development Impediment (SDI); Weight of Supplier Development Impediment (WSDI); Weight of Supplier Development Impediment Category (WSDIC); Normalized Weight of Supplier Development Impediment (NWSDI)											

Table 2.2.12 Structural Self-Interaction Matrix of Principal SDIs

	PTT	LMT	PDA	SRCp	PSF	LPM	PCF	MGO	PTK	SAC	LCW	NAR	LBE
PTT		A	A	A	A	A	A	A	A	A	A	A	A
LMT			A	A	V	X	A	V	A	A	A	A	A
PDA				V	V	V	V	V	V	V	A	A	A
SRCp					V	V	A	V	A	X	A	A	A
PSF						V	A	X	A	A	A	A	A
LPM							A	A	A	A	A	A	A
PCF								V	X	A	A	A	X
MGO									A	A	A	A	A
PTK										V	A	A	A
SAC											A	A	A
LCW												V	V
NAR													V
LBE													

Table 2.2.13 Initial Reachability Matrix of Principal SDIs

	PTT	LMT	PDA	SRCp	PSF	LPM	PCF	MGO	PTK	SAC	LCW	NAR	LBE
PTT	1	0	0	0	0	0	0	0	0	0	0	0	0
LMT	1	1	0	0	1	1	0	1	0	0	0	0	0
PDA	1	1	1	1	1	1	1	1	1	1	0	0	0
SRCp	1	1	0	1	1	1	0	1	0	1	0	0	0
PSF	1	0	0	0	1	1	0	1	0	0	0	0	0
LPM	1	1	0	0	0	1	0	0	0	0	0	0	0
PCF	1	1	0	1	1	1	1	1	1	0	0	0	1
MGO	1	0	0	0	1	1	0	1	0	0	0	0	0
PTK	1	1	0	1	1	1	1	1	1	1	0	0	0
SAC	1	1	0	1	1	1	1	1	0	1	0	0	0
LCW	1	1	1	1	1	1	1	1	1	1	1	1	1
NAR	1	1	1	1	1	1	1	1	1	1	0	1	1
LBE	1	1	1	1	1	1	1	1	1	1	0	0	1

Table 2.2.14 Final Reachability Matrix of Principal SDIs

	PTT	LMT	PDA	SRCp	PSF	LPM	PCF	MGO	PTK	SAC	LCW	NAR	LBE	DR. P	Rank
PTT	1	0	0	0	0	0	0	0	0	0	0	0	0	1	7
LMT	1*	1	0	0	1*	1*	0	1*	0	0	0	0	0	5	6
PDA	1*	1*	1	1*	1*	1*	1*	1*	1*	1*	0	0	1*	11	3
SRCp	1*	1*	0	1	1*	1*	1*	1*	0	1	0	0	0	8	5
PSF	1*	1*	0	0	1	1*	0	1	0	0	0	0	0	5	6
LPM	1*	1	0	0	1*	1	0	1*	0	0	0	0	0	5	6
PCF	1*	1*	1*	1*	1*	1*	1	1*	1*	1*	0	0	1	11	3
MGO	1*	1*	0	0	1	1*	0	1	0	0	0	0	0	5	6
PTK	1*	1*	0	1*	1*	1*	1*	1*	1	1*	0	0	1*	10	4
SAC	1*	1*	0	1*	1*	1*	1	1*	1*	1	0	0	1*	10	4
LCW	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1	1	1*	13	1
NAR	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	0	1	1*	12	2
LBE	1*	1*	1	1*	1*	1*	1*	1*	1*	1*	0	0	1	11	3
De.P	13	12	5	8	13	12	8	12	7	8	1	2	7	8.23	
Rank	1	2	5	3	1	2	3	2	4	3	7	6	4		8.31

Table 2.2.15 Level Partitioning of Principal SDIs

Level	SDIs
I	PTT, LMT, PSF, LPM, MGO, SAC
II	SRCp, PCF, PTK, LBE
III	PDA, NAR
IV	LCW

Table 2.2.16 Fuzzy Direct Relationship Matrix of Principal SDIs

	PTT	LMT	PDA	SRCp	PSF	LPM	PCF	MGO	PTK	SAC	LCW	NAR	LBE
PTT	0	0	0	0	0	0	0	0	0	0	0	0	0
LMT	0.9	0	0	0	0.5	0.7	0	0.9	0	0	0	0	0
PDA	0.9	0.5	0	0.7	0.9	0.7	0.9	0.7	0.9	0.9	0	0	0.5
SRCp	0.5	0.7	0	0	0.7	0.9	0.9	0.7	0	0	0	0	0
PSF	0.7	0.5	0	0	0	7	0	0	0	0	0	0	0
LPM	0.9	0	0	0	0.3	0	0	0.5	0	0	0	0	0
PCF	0.9	0.9	0.1	0.7	0.7	0.7	0	0.9	0.7	0.7	0	0	0
MGO	0.7	0.7	0	0	0	0.5	0	0	0	0	0	0	0
PTK	0.5	0.5	0	0.9	0.5	0.9	0.9	0.9	0	0.7	0	0	0.9
SAC	0.9	0.1	0	0.9	0.7	0.5	0	0.7	0.3	0	0	0	0.9
LCW	0.7	0.1	0.9	0.7	0.9	0.5	0.9	0.7	0.9	0.7	0	0.3	0.5
NAR	0.7	0.5	0.7	0.7	0.7	0.9	0.7	0.7	0.7	0.9	0	0	0.9
LBE	0.7	0.7	0	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0	0	0

Table 2.2.17 Final Converged Matrix of Principal SDIs

	PTT	LMT	PDA	SRCp	PSF	LPM	PCF	MGO	PTK	SAC	LCW	NAR	LBE	Dr.P	Rank
PTT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
LMT	0.7	0.7	0	0	0.5	0.5	0	0.5	0	0	0	0	0	2.9	6
PDA	0.9	0.9	0.1	0.9	0.7	0.9	0.9	0.9	0.7	0.7	0	0	0.9	8.5	3
SRCp	0.7	0.7	0.1	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0	0	0.7	7.1	4
PSF	0.5	0.5	0	0	0.5	0.5	0	0.5	0	0	0	0	0	2.5	7
LPM	0.5	0.5	0	0	0.5	0.5	0	0.5	0	0	0	0	0	2.5	7
PCF	0.7	0.7	0.1	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0	0	0.7	7.1	4
MGO	0.7	0.5	0	0	0.5	0.7	0	0.7	0	0	0	0	0	3.1	5
PTK	0.9	0.9	0.1	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0	0	0.7	8.7	2
SAC	0.9	0.9	0.1	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0	0	0.7	8.7	2
LCW	0.9	0.9	0.1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0	0	0.9	9.1	1
NAR	0.9	0.9	0.1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0	0	0.9	9.1	1
LBE	0.9	0.9	0.1	0.9	0.7	0.9	0.9	0.9	0.7	0.7	0	0	0.9	8.5	3
De.P	9.2	9.0	0.8	6.4	8.4	9.0	6.8	9.0	6.4	6.4	0.0	0.0	6.4		
Rank	1	2	6	5	3	2	4	2	5	5	7	7	5		
Dr.P: Driving Power; De.P: Dependence Power															

2.2.6 Managerial implications

The SD is proven to be a potential strategy available for a manufacturer to develop its supply base and have competent suppliers to contribute in the value addition process. Nonetheless, manufacturers are skeptical about the investments made in the SDPs as there are several SDIs (as shown in Tables 2.2.1-2.2.4) affecting the stipulated course of actions in the SD practice and are eventually limiting the beneficial returns from SD. By applying the proposed approach, a manufacturer can specifically identify the potential impediments in the SD practice and have a definite basis to develop appropriate mitigation strategies. The approach helps a manufacturer to bring consensus among the SD participants about the SDIs and have collective actions derived towards establishing a progressive SD environment. Moreover, by applying the proposed approach a manufacturer can be proactive in addressing the SDIs and can sustainably reduce the negative impact on the SDPs. Since the principal SDIs are identified in the process of application, a manufacturer can no longer have to confront with the incapacitated situations in the practice of SD. Also, since the driving and dependence powers of SDIs were determined and on their basis SDIs were classified, a manufacturer can effectively focus on the right SDIs (clustered in the driver quadrant, see Figure 2.2.5) and observe the effects by examining the right SDIs (clustered in the dependent quadrant, see Figure 2.2.5). Finally, the ISM model also directs a manufacturer to focus on the root cause of SDIs and visualize the interdependencies among the SDIs for decision making.

2.2.7 Sectional summary

In this section, a methodology has been proposed in order to study and analyze the SDIs and to subsequently draw the appropriate mitigation strategies. Wherefore, categorical lists of SDIs which mostly prevail in all the SD environments were identified and by applying FAHP and Pareto analysis the principal SDIs were shortlisted for further analysis for the case company. At this juncture on the whole, 13 SDIs were finally obtained as principal SDIs and then ISM-FMICMAC analysis was applied to rank, classify and establish structural relationship between the principal SDIs. On the basis of obtained rankings of SDIs, LCW and NAR were obtained as foremost in terms of driving capability and PPT in terms of dependence capability. Further, on the basis of both driving and dependence powers, the SDIs were classified in to four clusters using driver dependence diagram. On the basis of classification, the case company was suggested to stress on the SDIs clustered in the driver quadrant (i.e. LCW, NAR and PDA) to bring about changes in the system and on the SDIs clustered in the dependence quadrant (i.e. PSF, MGO, LMT, LPM and PTT) to observe the changes in the system. Finally, based on the structural relationship of SDIs, the case company was suggested to draw its action plans primarily targeting the SDIs such as, LCW, NAR and PDA. It was emphasized that once these SDIs are handled, the other SDIs will indirectly get resolved to a greater extent in the implementation of SDPs. Although, the obtained results were relevant for the case company, yet they cannot be generalized for all the manufacturing companies. However, any manufacturer can use the proposed methodology by setting up the SDIs relevant to its environment and address specific issues in implementing SDPs. This ends the discussion on the strategic analysis for mitigating the SDIs. The next section deals with the performance analysis of SDPs.

2.3 Sectional abstract for performance analysis of SPDs

The current section provides an approach that a manufacturer can periodically use to measure the performances of its SDPs. It also quantifies and indicates the specific Supplier Development Outcomes (SDOs) that a manufacturer has to concentrate in improving its SDPs. In this regard, the proposed methodology integrates fuzzy analytic hierarchy process (to determine the importance of SDOs), Pareto analysis (to choose the significant SDOs) and fuzzy logic (to periodically determine the performance indices and grades of the SDPs) methods to measure the performances of SDPs. In order to demonstrate the utility of the methodology, a case situation is presented where the performance measures of SDPs running at five key suppliers of an Indian turbine manufacturing company were determined. The main findings to mention are, by periodically applying the abovementioned methodology, the performance indices of a manufacturer’s SDPs can be measured, monitored and managed effectively. It is shown that the methodology is advantageous in clearly indicating the scope of improvement for the SDPs along the specific SDOs. To mention about the research implications: since the obtained results in this study are specific to a manufacturing environment, they may not be generalized. However, the generic list of SDOs mentioned in the section and the proposed approach can be used in any manufacturing environment for analyzing the performances of SDPs.

Under Managerial implications: the performance analysis of SDPs would help a manufacturer to know more about the functioning of its SDPs along the timeline and provide the scope for improvement. To highlight the originality, the proposed approach successfully measures and also grades the performances of SDPs. The results would enable the supplier development managers to effectively distribute their investments and efforts along the SDPs.

2.3.1 Introduction to performance analysis of SDPs

In competitively meeting the requirements of increasingly demanding customers, the manufacturers are often confronted with three sourcing alternatives with the non-performing suppliers. Among the sourcing alternatives, a manufacturer can opt for switching the supplier or acquire the supplier's technology or choose to develop the supplier through certain SDPs. Rather than switching the supplier or acquiring the supplier's technology, the choice of SDP is often considered to be the best among the sourcing alternatives that manufacturers can pursue. This is mainly due to the associated high switching and acquiring costs compared to the development costs (Routroy and Pradhan, 2013b). Besides the costs facet, the manufacturers tend to prefer SD with a view to establish long term strategic relationships with their preferred suppliers and achieve better integration, coordination and collaboration in the supply base (Kähkönen et al., 2015). Through SDPs, the manufacturers propose certain SD initiatives with their suppliers to reduce the supply uncertainties leading to improvement in the suppliers' performance (Dunn and Young, 2004; Krause et al., 2007; Mahapatra et al., 2012; and Kumar Pradhan and Routroy, 2014). For these, now-a-days the manufacturers tend to work with only preferred suppliers mainly to cut down the supply base size and to include only the reliable suppliers to do business (Rogerson, 2012). This includes the advantage of having a small group as Chakravarty (2014) points out how the communication becomes manageable and effective with the small group of suppliers. Moreover, in the increasingly competitive environments, the manufacturers are often compelled to increasingly outsource their non-core activities to the best of the suppliers in the industry, competitively develop the suppliers and compete through their core activities (Kumar and Routroy, 2014). Although, SD is proven to be a beneficial option for the manufacturers, nonetheless, developing all the suppliers may not be viable and economical (Carr and Pearson, 1999). Thus, SD is mostly restricted to the development of critical and strategic suppliers, the ones who have potential to be trusted suppliers, but are underperforming with respect to the manufacturer's expectations. It is to be noted here that while developing these key suppliers, the proposed SDPs may not be the same for all the suppliers due to inherent variability in the nature of supplies required. Hence, the investments and the quantitative and qualitative level of activities carried out under the SDPs vary with the types of suppliers. The SDPs have another aspect as well. The performance improvement of the suppliers may also vary over a period of time. So, once a supplier begins to perform optimally, the excess resources meant for its development can be redistributed to relatively underperforming suppliers to bring them up to the standard. Considering these issues, the manufacturers have to carefully observe these variations and accordingly allocate their investments in the SDPs. Thus, for a sustainable growth of a manufacturer and suppliers through SDPs, it is important to practice an approach to analyze the performances of SDPs that help to frame the future course of actions. The current study is an attempt to propose such an approach for analyzing the performances of various SDPs using FAHP, Pareto analysis and fuzzy logic methods demonstrated with a case study.

2.3.2 Literature review on supplier development outcomes

Majorly the supplier integration/ involvement in various value addition activities (especially in the new product development); supplier collaboration through direct/ indirect investments and relationship building; and supplier coordination to ensure availability of the inputs in right quantity at right time along the SC dynamics cannot be achieved through transactional and arms-length relationships with the suppliers (Mahapatra et al., 2012; Wagner, 2010; and Routroy and Pradhan, 2013b). Thus, when it comes to contracting to the strategic and critical supplies, the manufacturers are more cautious in having the developed suppliers along the multiple dimensions (i.e. with total cost perspective) in view of achieving long term competitive benefits (Routroy and Sunil Kumar, 2014). So as to achieve this many at times a manufacturer adopts SDP as a sourcing alternative, wherein the manufacturer orients the key suppliers to precisely fit in its strategies (i.e. in terms of suppliers' performance versus manufacturer's requirements) (Mahapatra et al., 2012). Through SDPs a manufacturer extends support to its key suppliers in order to competitively receive the effective and efficient supplies. Further, the best performance outcomes of SDPs must ideally be passed on to the up streams (among as well as along the various tiers of suppliers) of the SCs (Wagner, 2011; and Avery, 2008). Having said about the vitality of SDPs for a sustainable growth of a manufacturer and its suppliers, there are only few formal approaches for evaluating the performances of SDPs. Bai and Sarkis (2011) proposed an analytical model using grey based rough set theory for analyzing the SD practices by a buyer firm and to asisst in decision making regarding the investments. Dou et al. (2014) used grey based theory integrated with analytical network process in evaluating the green SDPs considering the operational and environmental factors. Although, there are certain studies related to performance outcomes and evaluation of SDPs available in the literature, the contexts presented exclusively do not include all the SDOs in the interest of manufacturer, supplier and both. Johnson et al. (1998) in their study discussed the importance of performance measurement systems and righly pointed out that in order to develop closer relationships with suppliers, rather than one way assessments of suppliers joint system would be more beneficial. The SDPs demand both manufacturer and supplier to responsibly participate in their planning and execution. So, by essentially fulfilling the SDOs in the interest of manufacturer, supplier and both through the SDPs, the manufacturers and suppliers would be implicitly drawn in successfully carrying out the SDPs. Moreover, none of the studies have integrated the evolution of SDPs over a period of time and have provided a basis for the redistribution of allocated resources among the SDPs. Traditionally, most of the researchers have suggested evaluating the suppliers and identifying the areas of improvement and then having a basis to choose a supplier for development. But, thereafter none of the studies have specifically focused on the dynamics of SDPs and suggested the optimal redistribution of investments and resources among the SDPs. The manufacturers have to proactively engage the SDPs as they evolve and also ideally transform the SDPs by exploring higher innovative advantages. Many researchers have pointed out different SDOs that can be obtained by conducting the SDPs. In this study, a critical review was conducted and a generic list of SDOs are identified. They were broadly classified into three categories such as SDOs in the interest of manufacturer, SDOs in the interest of supplier and SDOs in the interest of both. All these SDOs are further used depending upon the manufacturing environment and in determining the performances of SDPs. The literature review on SDOs along the said stakeholder’s interests are presented in the following sections.

2.3.2.1 SDOs in the interest of manufacturer

A manufacturer usually has certain expectations to be fulfilled through its SDPs and so it accordingly inducts investments across its key suppliers. Unless SDPs meet these expectations, manufacturer would not be satisfied, rather discouraged due to loss of investments. Although, primarily the cost, quality, and delivery time are considered as basic performance factors nonetheless, it is observed that hardly these basic dimensions are properly accounted in most of the manufacturing companies. Moreover, these basic dimensions cannot be directly measured and base the decisions directly in many manufacturing environments. Thus, a generic list of SDOs that can comprehensively ensure overall improvement of the manufacturer are identified and their brief description along with the references are shown in the Table 2.3.1.

2.3.2.2 SDOs in the interest of supplier

A supplier shows resistance to the deployment of SDPs, as often manufacturer acts or at least perceived as exploitative and mostly tries to extract more value out of the returns transferred. Moreover, suppliers tend to become opportunistic as long as the manufacturer keeps practicing win-lose strategies despite the suppliers' best efforts in providing their services and if their interests are kept ignored. Thus, a generic list of SDOs in the interest of supplier are identified and their brief description along with the references are shown in the Table 2.3.2.

2.3.2.3 SDOs in the interest of both supplier and manufacturer

There are certain SDOs which mutual attract the interests of suppliers as well as a manufacturer. These SDOs cannot be expected to be fulfilled by either of the party individually, but both manufacturer and supplier have to collectively work together in meeting their expectations. A generic list of SDOs in the interest of both suppliers and manufacturer are identified and their brief descriptions along with the references are shown in the Table 2.3.3. The generic lists of SDOs along the stakeholders' (i.e. manufacturer, supplier and both) interests are obtained through literature review, brainstorming sessions and discussions held with the practicing managers. However, the lists may not be exhaustive as well as mutually exclusive, it is quite possible that there may be some correlation between the SDOs which can be further explored by studying the relationships between the SDOs. Although it may not be said that the SDOs are mutually exclusive, the presence or absence of an SDO will definitely have impact on the satisfaction of a manufacturer and/ or its suppliers. So, even though if there are some interactions overall the potential SDOs have to be considered in fulfilling the stakeholders interests. In the current study, the possible interactions between the SDOs are not considered but, in stricter terms the study can be extended in future by considering the interactions between the SDOs. The proposed methodology can be integrated with analytical network process/ rough set theory/ decision making trial and evaluation laboratory/ interpretive structural model methods even by incorporating fuzzy and rough set theories to account the interdependencies in between the SDOs.

Table 2.3.1 Supplier development outcomes in the interest of manufacturer

MIOs	Description	References
PPQ	Improvement achieved in a supplier’s product as well as packaging quality.	(Motwani et al., 1999), (Takeishi, 2001), (Holmen and Kristensen, 1998), and (Handfield et al., 2000)
IAP	Improvement in the availability of a supplier’s products and services.	(Krause and Ellram, 1997a), (De Toni and Nassimbeni, 2000), (Gadde and Snehota, 2000), and (Bai and Sarkis, 2014)
INR	Nimble innovation support from a supplier.	(Routroy and Pradhan, 2013a), (Lawson et al., 2014), (Pulles et al., 2014), (Rotich et al., 2014), (Inemek and Matthyssens, 2013), (Wang et al., 2004) and (Yan and Dooley, 2014)
PPS	Improved supplier’s response in the maintenance and other valued added services.	(Vrat, 2014), (Erdem and Göçen, 2012), and (Zouggari and Benyoucef, 2012)
ESF	Improvement in a supplier’s ability to tailor and accommodate changing demands and requirements.	(Mahapatra et al., 2012), (Bai and Sarkis, 2014), (Chiang et al., 2012),(Jin et al., 2014) and (Handfield et al., 2014)
ICS	Improved downstream customers’ satisfaction.	(Lu et al., 2012), and (Wynstra et al., 2012)
INR	Improved supplier’s consistency across various dimensions in providing the products/ services.	(Routroy and Pradhan, 2013a), (Zouggari and Benyoucef, 2012) and (Chiang et al., 2012)
IRI	Improved responsibility taken by a supplier on the supplied products and services.	(Lawson et al., 2014), (Zhao et al., 2014), and (Raafat et al., 2012)
ICM	Ease in the implementation of proposed changes with no/ low supplier’s resistance.	(Li et al., 2012), (Dou et al., 2014a), and (Arráiz et al., 2013)
RSC	Smooth running of transactions with no/ minimal complaints and conflicts.	(Krause et al., 2007), (Lam and Chin, 2005), and (Lam et al., 2007)
EFC	Supplier’s support extended to a manufacturer in focusing on the core competencies.	(Kumar Pradhan et al., 2014), (Routroy and Pradhan, 2013a), (Lawson and Potter, 2012), (Prajogo et al., 2012), and (Sharma and Yu, 2013)
IAW	Improved manufacturer’s ability to access and implement world class manufacturing.	(Kumar and Routroy, 2014), (Raafat et al., 2012) and (Chavhan et al., 2012)
SREp	Supplier's responsiveness in incorporating the customers’ requirements.	(Handfield et al., 2014), (Danese et al., 2013), (Thatte et al., 2013), (Routroy and Kumar Pradhan, 2014), and (Talluri et al., 2013)
ICMf	Improved customer status of a manufacturer from a supplier’s perspective.	(Pulles et al., 2014), (Schiele et al., 2012), (Nagati and Rebolledo, 2013), and (Baxter, 2012)
IPS	Manufacturer’s ability to strategically treat their preferred suppliers.	(Wynstra et al., 2012), and (Ivens et al., 2013)
Product and Packaging Quality (PPQ); Improved Availability of Products (IAP); Innovation Support Received (INR); Post Purchase Service (PPS); Enhancement of Supplier Flexibility (ESF); Increased Customer Satisfaction (ICS); Increased Supplier Reliability (ISR); Improved Responsibility on the Inputs (IRI); Improved Change Management (ICM); Reduced Supplier Complaints (RSC); Effective Focus on Core Competencies (EFC); Increased Access to World class capabilities (IAW); Supplier Responsiveness (SREp); Improved Customer status of the Manufacturer (ICMf); Improved treatment of Preferred Suppliers (IPS)		

Table 2.3.2 Supplier development outcomes in the interest of supplier

OSIs	Description	References
ISS	Improved position of a supplier in terms of preferential selection.	(Chang et al., 2011), and (Koufteros et al., 2012)
ISC	Improved trust and faith in a manufacturer's dealings.	(Routroy and Pradhan, 2013a), (Smets et al., 2013), and (Fawcett et al., 2012)
RPR	Supplier's efforts are valued not only in terms of price but also along the other contributions.	(Routroy and Sunil Kumar, 2014), and (Praxmarer-Carus et al., 2013)
EPM	Manufacturer's ability to adapt with the changes along the product life cycles.	(Mahapatra et al., 2012), (Wagner, 2011), (Nagati and Rebolledo, 2013), (Friedl and Wagner, 2012), and (Doha et al., 2013)
IBM	Improved supplier's share of outsourcing in terms of value and volume of business from a manufacturer.	(Wagner, 2011), (Dou et al., 2014a), (Nagati and Rebolledo, 2013), (Srivastava and Singh, 2013), and (Blonska et al., 2013)
IBI	Improvement achieved in the conditions of a supplier's backward integration.	(Hofmann et al., 2013), (Adewuyi and Oyejide, 2012), and (Gupta and Narain, 2012)
ICO	Consistency achieved in the orders/ services from a manufacturer.	(Wang et al., 2004), and (Arroyo-López et al., 2012)
RIM	Business/ value returns for the innovation transfers from a supplier.	(Pulles et al., 2014), and from experts' thoughts
IRL	Length for which a supplier is made to associate with a manufacturer.	(Wagner, 2011), (Prajogo et al., 2012), (Hammervoll, 2012), and (Adams et al., 2012)
ICE	Project partnerships awarded to a supplier.	(Wagner, 2011), (Zhao et al., 2014), (Koufteros et al., 2012), and (Roloff et al., 2015)
IPC	Improved strategic ability of a supplier to provide best of the inputs and services to its preferred customers.	(Ellegaard and Koch, 2012), (Narayanan et al., 2014), and from experts' thoughts
Improved Supplier Selection (ISS); Improved Supplier Confidence (ISC); Reduced emphasis on Price Reduction (RPR); Efficient Product life cycle management (EPM); Increased Business from the Manufacturer (IBM); Improved conditions of Backward Integration (IBI); Improved Consistency in the Orders (ICO); Returns on Innovation offered by the Manufacturer (RIM); Improved Relationship Length (IRL); Increased Collaborative Efforts from the manufacturer (ICE); Improved service to Preferred Customer (IPC)		

Table 2.3.3 Supplier development outcomes in the interest of both sides

OIB	Description	References
ISE	Improvement achieved in the value addition with minimum spend of resources.	(Bai and Sarkis, 2011), (Lawson et al., 2014), (Vrat, 2014), (Raafat et al., 2012), (Li et al., 2012),(Arráiz et al., 2013), (Prajogo et al., 2012), (Danese et al., 2013), (Nagati and Rebolledo, 2013), (Praxmarer-Carus et al., 2013), (Blonska et al., 2013), and (Arroyo-López et al., 2012)
IRP	Improvement achieved in the SC ability to respond to the market requirements.	(Bai and Sarkis, 2011), (Lawson et al., 2014), (Vrat, 2014), (Raafat et al., 2012), (Li et al., 2012),(Arráiz et al., 2013), (Prajogo et al., 2012), (Danese et al., 2013), (Nagati and Rebolledo, 2013), (Praxmarer-Carus et al., 2013), (Blonska et al., 2013), and (Arroyo-López et al., 2012)
REI	Improved materials management from SC perspective.	(Lawson et al., 2014), and (Danese et al., 2013)
ISD	Development of human resource knowledge, exposure, skills, experience and expertise achieved.	(Bai and Sarkis, 2014), and (Nagati and Rebolledo, 2013)
RBR	Reduced risks and effective risk management strategies developed improving overall SC resilience.	(Lawson et al., 2014), (Friedl and Wagner, 2012), and (Brashear Alejandro et al., 2013)
ISCt	Improved competitiveness achieved and competitive advantages developed through SDPs.	(Bai and Sarkis, 2011), (Lawson et al., 2014), (Vrat, 2014), (Raafat et al., 2012), (Li et al., 2012),(Arráiz et al., 2013), (Prajogo et al., 2012), (Danese et al., 2013), (Nagati and Rebolledo, 2013), (Praxmarer-Carus et al., 2013), (Blonska et al., 2013), and (Arroyo-López et al., 2012), and (Esteves and Ivanova, 2013)
ICR	Improvement in the brand value of the products/ services.	(Routroy and Sunil Kumar, 2014), (Dou et al., 2014a), and (Kotula et al., 2015)
IRS	Improved relationship strength and reach achieved between buyer and supplier.	(Wagner, 2011), (Raafat et al., 2012) and (Praxmarer-Carus et al., 2013)
IKD	Right knowledge base developed by documenting the learning achieved in handling the significant dynamics.	(Bai and Sarkis, 2014), (Lawson et al., 2014), (Handfield et al., 2014), (Zhao et al., 2014), (Lawson and Potter, 2012), (Blonska et al., 2013), and (Cousins et al., 2011)
IWM	Developed methods in extracting more value out of waste besides its efficient handling.	(Deshmukh and Vasudevan, 2014), and (Wilding et al., 2012)
IGC	Environmental conscious methods adopted by the company.	(Dou et al., 2014a), and (Dou et al., 2014b)
BSP	Regular exercise of performance management and feedback systems.	(Wagner, 2011), (Vrat, 2014), (Li et al., 2012) and (Arroyo-López et al., 2012)
ITO	Improved supplier technological and operational abilities.	(Kumar Pradhan et al., 2014), (Lawson et al., 2014) and (Arroyo-López et al., 2012)
ISMg	Ease in planning, execution, control, evaluation and improvement of and by the manufacturer and supplier.	(Handfield et al., 2014), and (Koufteros et al., 2012)
Improved SC Efficiency (ISE); Improved SC Responsiveness (IRP); Reduction in Inventory levels (REI); Improved buyer supplier Skill Development (ISD); Reduced Buyer supplier Risks (RBR); Improved SC Competence (ISCt); Improved Corporate Reputation (ICR); Improved Relationship Strength (IRS); Improved Knowledge base Development (IKD); Improved Waste Management (IWM); Improved Green Capability (IGC); Buyer-Supplier Performance management (BSP); Improved Technological and Operational abilities (ITO); Improved Supply Management (ISMg)		

2.3.3 Methodology for analyzing the SDPs

The intended research objective is to analyze the performance of various SDPs running by a manufacturer and provide a basis for the manufacturer to monitor and continuously improve the performances of its SDPs. The proposed methodology mainly involves three stages, (a) application of FAHP, (b) Pareto analysis, and (c) fuzzy logic. In stage (a) by applying the FAHP, the weights ascribed to the SDOs are determined with respect to the manufacturing environment. In stage (b) the significant SDOs are shortlisted on the basis of obtained weights in the stage (a). In stage (c), the fuzzy logic method is applied on the significant SDOs (obtained from stage (b)) to determine the performances of SDPs. Before getting into the details of the methodology, at this juncture it must be noted that the data collection process is limited to the manufacturer's personnel alone. This is due to safely prevent the unnecessary provocation created in the suppliers to expect more out of SDPs. Nonetheless, it is not to say that suppliers' component must be ignored but to have proper balance in the planned SDPs without overlooking the basic and gross interests of the supplier. For this, the manufacturer's bottom line personnel who are closely related to the suppliers must also be included in the data collection process. Moreover, since SDPs are the manufacturer's initiatives, who has to sustain relatively more costs and responsibility than the suppliers, data collection from a manufacturer's point of view should be unbiased for establishing the efficient and effective SDPs. The step by step procedure of the proposed methodology along with flow chart (see Figure 2.3.1) is explained as follows,

(a) Procedural steps for applying FAHP

The following steps of FAHP are applied out to come out with the weights ascribed to the SDOs:

Step 1: Formation of Cross Functional Teams (CFTs)

CFTs of experts from various departments on the manufacturer side are drawn for data collection. The teams formed must have a proper balance of experience, expertise, knowledge and those who closely transact with the suppliers.

Step 2: Definition of SD Environment

SD environment represents the nature of a manufacturer and the suppliers it is working with. In general it is characterized by the types of supplies, nature of supply market, amounts of business transactions, operational setups, scales of manufacturing, nature of demand and including all other considerations specific to the environments that can influence the SDPs.

Step 3: Identification of relevant SDOs

Identify the categories of performance outcomes that reflect interests of suppliers, manufacturer and both in common. These outcomes can be obtained through literature review, brainstorming sessions and discussions with CFTs' experts. These performance outcomes must be screened further to determine the right outcomes suitable for the environment.

Step 4: Performance of screening tests on SDOs

A series of screening tests are to be essentially conducted before proceeding to further analysis of SDPs. In the screening tests, the SDOs are checked for relevancy, redundancy, accountancy, gross level of significance and directional tests to identify the right set of performance outcomes. In the relevancy test, the SDOs are checked for their pertinence to the SD environment defined in the step 2. In the accountancy test, the SDOs are tested to see whether or not all the necessary and sufficient performance outcomes of SDPs are considered. In the redundancy test, the SDOs are checked for any sort of duplication and the repeated outcomes if any are eliminated from the lists. In the gross level significance test, the SDOs which are grossly unimportant must be safely eliminated from the lists, to rightly direct the energy and resources on the right outcomes. Finally, in the directional test, all the SDOs are made consistent with respect to the type of influence (direct/indirect) they have on the performance of SDPs. Thus, by conducting all the aforementioned screening tests, a manufacturer can arrive at the right list of SDOs to be considered for analysis.

Step 5: Determination of Fuzzy Synthetic Extents (FSEs) and weights

FAHP method is to be used to determine the FSEs and weights of stakeholders' interests and their corresponding SDOs. The FSEs are expressed in terms of Triangular Fuzzy Numbers (TFNs). The FSE of a stakeholder interest or a SDO '*i*' it is denoted by $W_i = \left(m_i^-, m_i, m_i^+ \right)$. The following seven steps demonstrate the procedure for determining the FSEs:

Step 5.1: Construction of pair wise comparison matrices of outcomes

The relative importance between the stakeholders' interests along with their corresponding SDOs in the form of Pair Wise Comparison Matrices (PWCMs) from each CFT are to be collected. These pair wise comparisons are to be made on a 1-9 scale (Saaty, 1990) (See Table 2.3.4).

Table 2.3.4 Scale for pairwise comparisons (Source: Saaty, 1990)

Importance measure	Definition
1	Equally important
2	Equally to moderately important
3	Moderately important
4	Moderate to strongly important
5	Strongly important
6	Strongly to very strongly important
7	Very strongly important
8	Very strongly to extremely important
9	Extremely important

Step 5.2: Consistency check of pair wise comparison matrices

The consistency in the comparisons made between the stakeholders' interests/ SDOs through CFTs must be crosschecked to ensure that the pair wise comparisons performed are without any contradictions in the opinions. This consistency check of the comparisons is made on the basis of Consistency Ratio (CR). It is calculated as follows, the values in each column of the PWCMs are normalized by dividing each entry by the sum of the column wise entries. Then the average of the entries across each row is determined. This forms the Principal Vector (PV). If the pair wise comparison matrix is denoted as M_1, and the principal vector is denoted as M_2, then $M_3 = M_1 * M_2$ and $M_4 = M_3/M_2$. If λ_{max} is the average of the outcomes of M_4, then the Consistency Index *(CI)* can be calculated by, $CI = \frac{\lambda_{max} - N}{N - 1}$, where '*N*' is the number of SDOs under corresponding stakeholder's interest. The Consistency Ratio *(CR)* is calculated by, $CR = \frac{CI}{RI}$, where *RI* is the Random Index corresponding to '*N*' (See Table 2.3.5).If the *CR* value is less than or equal to 10% (allowed percentage of error in the consistency), then the judgments can be considered consistent. If not, the CFTs have to improve their judgments in such a way that CR≤ 10% (Saaty, 1990).

Table 2.3.5 Random Index values (Source: Saaty, 2000)

Number of outcomes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Random Index	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Step 5.3: Fuzzification of pairwise comparison matrices of each CFT (Lee, 2009)

The data collected in the form of PWCM from each CFT are fuzzified by replacing its elemental values with the corresponding TFNs (as shown in the Table 2.3.6). The TFNs corresponding to the comparison of a stakeholders' interests/ a SDO 'i' with 'j' for the CFT 'k' is denoted by $(P_{ijk}, Q_{ijk}, R_{ijk})$.

Table 2.3.6 Membership functions of the fuzzy numbers (Source: Lee, 2009)

Crisp judgment of the pairwise matrix	Triangular fuzzy number
1	(1,1,2)
2	(x-1, x, x+1) for x = 2,3,…,8
9	(8,9,9)
1/1	$(2^{-1},1^{-1},1^{-1})$
1/x	$((x+1)^{-1},x^{-1},(x-1)^{-1})$ for x = 2,3,…,8
1/9	$(9^{-1},9^{-1},8^{-1})$

Step 5.4: Integration of fuzzified pair wise comparison matrices

The fuzzified PWCMs are integrated by means of geometric mean method using the expressions shown below (Lee, Kang and Chang, 2009). The resultant integrated matrix constitute of elements in TFNs denoted by (a_{ij}, b_{ij}, c_{ij}).

$$a_{ij} = \left\{ \prod_{t=1}^{s} P_{ijk} \right\}^{1/s} \quad \forall i, j = 1, 2, \ldots, N$$

$$b_{ij} = \left\{ \prod_{t=1}^{s} Q_{ijk} \right\}^{1/s} \quad \forall i, j = 1, 2, \ldots, N$$

$$c_{ij} = \left\{ \prod_{t=1}^{s} R_{ijk} \right\}^{1/s} \quad \forall i, j = 1, 2, \ldots, N$$

Where, 's' denotes the number of CFTs formed for the data collection.

Step 5.5: Determination of FSEs of stakeholders' interests and SDOs

The FSE for each stakeholder's interests/ SDO 'i' denoted by W_i is calculated as shown below ((Lee, 2009); (Lee, Kang and Chang, 2009); (Lee, Kang, Hsu, et al., 2009) and (Chang, 1996)):

$$W_i = \left(m_i^-, m_i, m_i^+\right) = \left\{ \frac{\sum_{j=1}^{N} a_{ij}}{\sum_{i=1}^{N}\sum_{j=1}^{N} c_{ij}}, \frac{\sum_{j=1}^{N} b_{ij}}{\sum_{i=1}^{N}\sum_{j=1}^{N} b_{ij}}, \frac{\sum_{j=1}^{N} c_{ij}}{\sum_{i=1}^{N}\sum_{j=1}^{N} a_{ij}} \right\} \forall i = 1,2,\ldots,N$$

Step 5.6: *Calculation of Degree of Possibilities*

The FSE of each stakeholder's interests/ SDO is compared with the FSEs of the rest of the stakeholders' interests/ SDOs respectively and a value called Degree Of Possibilities (DOPs) $\mu(F_i)$ (Chang, 1996; and Zhu et al., 1999) are calculated as mentioned below.

$$\mu(F_2 \geq F_1) = \begin{cases} 1, & m_2 \geq m_1 \\ 0, & m_1^- \geq m_2^+ \\ \dfrac{[\, m_1^- - m_2^+]}{[(m_2 - m_2^+) - (m_1 - m_1^-)]} & otherwise \end{cases}$$

Step 5.7: *Determination of weights*

The minimum value among the DOPs ($\mu(F_i)$) of stakeholders' interests/ SDO 'i' will be the weight ascribed for the respective stakeholders' interests/ SDO. By following the above procedural steps, weights attached to the interests of stakeholders as well as and their corresponding SDOs can be obtained. Further the weights of SDOs should be normalized through weights given to the stakeholder's interests.

This ends the application of FAHP technique used to determine the weights of SDOs.

(b) Pareto analysis

The Pareto analysis is conducted to shortlist the significant SDOs that majorly influence the SDPs. For this, the normalized SDOs obtained in the previous stage are plotted on a Pareto chart and the significant SDOs are shortlisted on the basis of 80-20 rule so as to have vital few rather than trivial many.

(c) Fuzzy logic

By taking the significant SDOs obtained in the previous stage, the fuzzy logic method is applied to determine the performances of various SDPs. The following steps present the procedure for applying the fuzzy logic:

Step 1: Determination of average fuzzy performance rating for each significant SDO

The Performance Ratings (PRs) along each significant SDO of a SDP running at a supplier must be collected from the CFTs across the multi timeline (i.e. in the past, present and future). Then Average of the PRs (APRs) collected from all the CFTs across respective timeline must be calculated. The procedure for finding the APRs of outcomes is mentioned below:

Step 1.1: Collection of CFTs' opinions on performance rating of each SDO

Collect the Performance Ratings (PRs) of SDOs in terms of linguistic expressions along past, present and future timeline from the CFTs. These linguistic expressions are replaced by corresponding TFNs as per Table 2.3.7.

Table 2.3.7 Linguistic judgements for performance ratings (Source: Vinodh et al., 2013)

Linguistic Expressions	Notation for expression	Corresponding TFN
Worst	W	(0,0.5,1.5)
Very Poor	VP	(1,2,3)
Poor	P	(2,3.5,5)
Fair	F	(3,5,7)
Good	G	(5,6.5,8)
Very Good	VG	(7,8,9)
Excellent	E	(8.5,9.5,10)

Step 1.2: Determination of average fuzzy performance rating

Determine the APR of each SDO (with respect to past, present and future timeline) by aggregating the multiple decision inputs using the arithmetic mean method. The APR of a SDO 'i', along the timeline 't' is denoted by R_{it} and calculated using the following equation.

$$\overline{R_{it}} = \frac{\sum_{k=1}^{s} R_{itk}}{s} \; \forall t = 1, 2, \ldots, n; \forall i = 1, 2, \ldots, N$$

Step 2: Calculation of Fuzzy Performance Measure (FPM)

The FPM along each timeline (past, present and target) under the respective stakeholder's interest is calculated by using the following equation:

$$FPM = \frac{\sum_{i=1}^{N} (W_i \otimes \overline{R_{it}})}{\sum_{i=1}^{N} (W_i)} \; \forall t = 1, 2, \ldots, n;$$

Step 3: Measuring Euclidean distances from predetermined preferential levels

The SDP's performance grading levels are to be predefined in consultation with the CFTs' members along with their expressions in terms of TFNs (see Table 2.3.8). These expressed TFNs are largely environment specific and so, they cannot be generalized. Then, the Euclidean distance of FPMs with reference to these predefined preferential levels are computed using the equation shown below:

Table 2.3.8 SDPs' predefined performance grading levels and corresponding TFNs

Predefined Performance Grading Levels of SDPs (PGL_k)	**Corresponding TFN ($f_{PGL_k}(x)$)**
A Grade	(7,8.5,10)
B Grade	(5.5,7,8.5)
C Grade	(3.5,5,6.5)
D Grade	(1.5,3,4.5)
E Grade	(0,1.5,3)

(Source: Vinodh et al., 2013)

$$D\,(FPM_t,\ PGL_k) = \left\{ \sum_{x \varepsilon p} (f_{FPM}(x) - f_{PGL_k}(x))^2 \right\}^{1/2}$$

$$\forall t = 1, 2, \ldots, n; \forall k = \{A, B, C, D, E\}$$

Where $f_{FPM}(x)$ represents the Fuzzy Performance Measure

$f_{PGL_k}(x)$ represents the predefined performance grading level $'k'$

Step 4: Determination of SDP Performance Index (SDPPI)

The minimum among the Euclidean distances (measured from the predefined performance grading level) represents the corresponding SDP's performance grade of a supplier with respect to the timeline. Table 2.3.8 shows the predefined preferential levels along with their corresponding TFNs.

Step 5: Plotting the SDP performance along the SDOs

Through the weights of stakeholder's interests and the APRs of SDOs obtained in the step 1.2 the Weighted APRs (WAPRs) are to be calculated. These WAPRs are to be transformed into crisp scores by using the equation of defuzzification (Kwong and Bai, 2003). It is given by: $CS_{ij} = (l_{ij} + 4m_{ij} + n_{ij})/6$ where, CS_{ij}: Crisp score ; l_{ij}: left spread of the performance measure; m_{ij}: mean value of the performance measure;n_{ij}: Right spread of the performance measure. By plotting these crisp scores along the SDOs, manufacturer can clearly get to know which SDOs it has to improve in a SDP.

The abovementioned procedure was coded into a simple application program in MATLAB 2013b with which a manufacturer can easily run the analysis and visualize the results without going through the computational burden. The competence of this system is testified by implementing in a turbine manufacturing company in India and analyzing the end results.

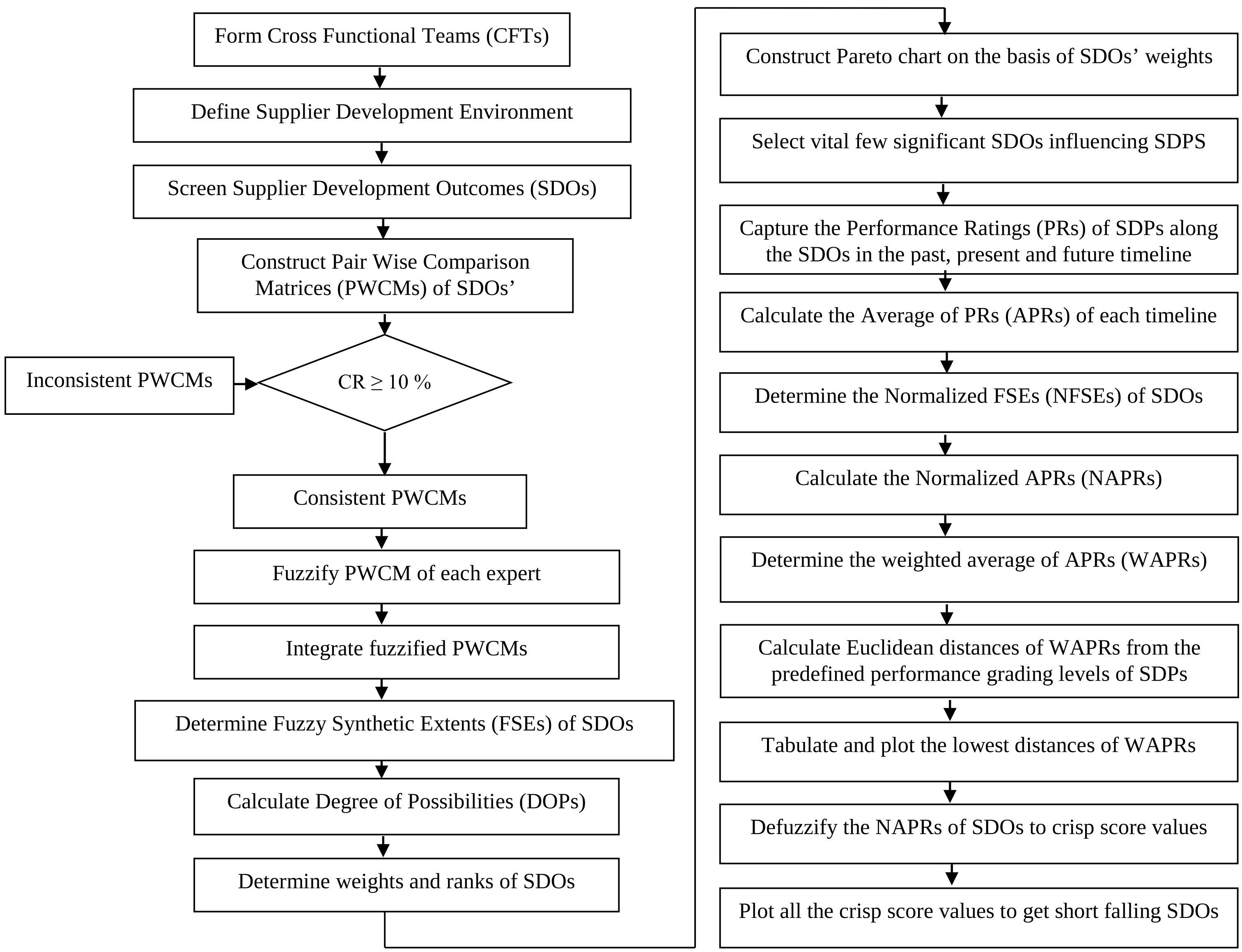


Figure 2.3.1 Proposed methodology for performance analysis of SDPs

2.3.4 Application of proposed methodology in a turbine manufacturing company in India

The above discussed methodology was applied to a turbine manufacturing company in India. The case company is referred as 'X' in the current discussion adhering to the confidentiality terms and conditions of the company. The company 'X' is a prominent competitor and holds a well-known brand in the energy market. It mainly manufactures turbines and has state-of-the-art manufacturing facilities in India and abroad. It also started providing customized as well as integrated engineering solutions according to the client's requirements besides the equipment manufacturing. It has been successful because of its relatively early entrance into the market and high competitive standards maintained across the organization. It has been competitive mainly through its high quality and reliable supplies offered at competitive prices and efficient project completion. Right from its commencement, it maintained a winning track record and achieved huge profits. Because of its diversified businesses, models and strategies, it has created a strong financial base for itself. It is very responsive to the customers' requirements and is strategically investing in R&D to develop and build latest innovative technologies. It has been increasing its global presence by understanding and providing solutions to the needs of wide range of customers. The company is very conscious of upgrading the knowledge and skills of its human resources and also effective in balancing their experience and expertise level. It has been actively promoting training sessions and extending sponsorship opportunities to its employees. The company claims and acknowledged by its customers that its supplies are easy and inexpensive to operate and maintain. Customers' feedback has been excellent because of its transparency, ethical standards and high responsive after sales services. Complaints/ any issues are addressed at a recorded level of time and the same are used in developing competitive spirit among its employees as well as attracting the customers. Clear policies have been developed and being implemented by the company across all of its businesses and sites to ensure commonality in the thought patterns and course of actions of every employee in fulfilling the different customers' requirements. It has acquired all the necessary certifications and have become well versant with regards to rules and regulations of different governing bodies. It has been improving its position consistently by improving its quality and project completion ability. It has partnered the technology development and outsourced certain strategic supplies to the key suppliers of the industry. In order to avoid the monopoly of a single supplier, the company has explored multiple suppliers along its key supplies. However, of the multiple suppliers few key suppliers were preferred in developing long term relationships and in turn deployed SDPs. The SDPs in the company were targeted to ensure that all the basic objectives are met and eventually to evolve the relationships with suppliers, reap extra benefits and privileges. Although the company was supporting its suppliers through various SD initiatives, there was no proper accountability on which SDP it has to significantly invest and in which areas to invest. Most of the decisions made were reactive in nature and not properly planned, executed and accounted. Even though there was improvement in some suppliers' performances and benefits from the suppliers, there was no proper evidence for the company to channelize its investments. The company was not knowing which SDP was doing well and which one was lagging and so it was not optimally investing in the SDPs. Since there were twenty SDPs running at the company, it was also difficult for the company personnel to thoroughly follow up the functioning of SDPs and to proactively identify the areas of improvements along the SDPs.

Having said about the case company, its suppliers and SDPs, CFTs were formed by drawing the personnel from the various departments dealing with the suppliers. Totally three CFTs (A, B and C) were formed by maintaining an average experience of the CFTs with the case company as twelve years and number of members in each CFT as six. The generic lists of SDOs discussed in the literature review (see Section 2.3.2) in the interest of supplier, manufacturer and both were shared with the CFTs and the objectives of the study were clearly conveyed. Even though screening tests were performed there was no consensus among the CFT members in the elimination of certain SDOs and so all the SDOs described in the Section 2.3.2 were considered for analyzing the performances of SDPs. Thus, altogether forty SDOs were considered for the analysis of SDPs. Following the step 5 of stage (a) in the Section 2.3.3, weights of stakeholders' interests and their corresponding SDOs were determined. As per step 5.1, four PWCMs were formed on the basis of Table 2.3.4, out of which three PWCMs were among the SDOs along the stakeholder's interests and one was in between the stakeholders' interests. Further, these PWCMs were checked for consistency in the comparisons. After passing through the consistency check, the PWCMs were fuzzified and integrated. As per step 5.5, the FSEs of stakeholders' interests and their corresponding SDOs were determined. Then, as explained in the step 5.6, the DOPs were calculated. On the basis of DOPs, according to step 5.7, the weights of stakeholders' interests and their corresponding SDOs were determined. Thereafter, through the weights of stakeholder's interests, the weights of SDOs were normalized (see Table 2.3.9). On these normalized SDOs, the Pareto analysis (see stage (b)) was conducted to shortlist the significant SDOs influencing the SDPs' performances. After conducting the Pareto analysis, twenty seven out of forty SDOs were shortlisted for further analysis (see Figure 2.3.2).

Although there were twenty SDPs running by the company 'X', as per CFTs' choice the performance analysis was conducted on five SDPs running at the suppliers (named as S1, S2, S3, S4 and S5 for demonstration). At this juncture, the PRs in the form of linguistic expressions along the significant SDOs were collected as per Table 2.3.7. The PRs were collected for over a period of three years along the three timelines (i.e. past year, present year and next/ future year) by the three CFTs (named as A, B, C). These PRs were transformed into corresponding to TFNs (PRs) and were averaged to obtain APRs. These APRs were weighted averaged (see Table 2.3.10) to obtain the FPMs of the SDPs. On the basis of these FPMs, the Euclidean distances were calculated from the predefined SDP performance grading levels (see Table 2.3.8). According to step 4 of stage (c), the minimum among the Euclidean distances from the grading levels indicates the SDPPI and its corresponding grade. The output related to SDPPIs of five SDPs along the three timelines are shown in the Table 2.3.11. Finally, as per step 5 of stage (c), WAPRs were determined and were defuzzified and plotted on bar charts for better interpretation of variation in the SDPPIs (i.e. through SDOs at a micro level) along the timeline.

2.3.5 Results and discussions

After applying the FAHP method, the weights ascribed for the stakeholder's interests in the case company's SD environment were, 0.565 to the interests of manufacturer, 0.304 to the interests of both and 0.131 to the interests of supplier. Thus, it can said that the SDPs' performance in the case company's environment are primarily aimed to fulfill manufacturer's interests. This also indicates that the company X's suppliers do not pull the manufacturer to share more value out of SDPs. While, on the basis of weights given to the SDOs and after conducting the Pareto analysis, significant SDOs were shortlisted. From the obtained significant SDOs, it was observed that ESF, ICS, IRI, INR, SREp and PPS were relatively predominant in deciding the performance of SDPs. Nonetheless, all the significant SDOs were considered in determining the SDPPIs of SDPs. Through the normalized FSEs and APRs, WAPRs of SDPs were obtained whose Euclidean distances were measured from the predefined reference levels indicating the SDP performance grading. Table 2.3.11 shows the obtained SDPPIs of all the five SDPs running at S1, S2, S3, S4 and S5 along with their corresponding grades across the three timelines. It can be observed that all the suppliers achieved substantial improvement in their performances through the SDPs, with further scope in the performance improvement. However, SDP at S1 is expected to achieve 'A' grade performance level; SDPs at S2, S3 and S4 are expected to achieve 'B' grade performance level and SDP at S5 is expected to remain at the same level (i.e. at 'B' grade level). Having obtained the performance projections, now the manufacturer have to take necessary actions to push the performance levels of the SDPs accordingly. To arrive at the decisions for improvement in the SDPs of the case company (i.e. along which SDOs the SDP is lacking and which SDOs preferably be improved) the crisp scores of WAPRs were determined. According to step 5 of stage (c), the crisp scores of WAPRs along the present and future timelines were calculated and plotted on a bar chart (see Figure 2.3.3). This comparison of SDPs' performances along the SDOs across the present and future timelines help the manufacturer to know expected rise/fall in the performances of SDOs. Here in the situation of case company, it was observed that all the projected performances are on the positive side. However, from the performance analysis plot of all the SDPs along the SDOs, the manufacturer has to pick which SDOs it has to stress for improvement. For instance in the case of S1, it is expected to achieve 'A' grade performance level while it can be observed that even in the future, supplier 'A' is expected lacking in IRI and ISE. Thus, to improve the performance of SDP at S1, the case company has to focus on developing the supplier responsibility over its supplies and then it can focus on making the SDP operations efficient. For improving supplier responsibility, a manufacturer can choose to distribute the payments made to the suppliers at different phases. For making the SDP operations efficient, the manufacturer can use certain techniques like value stream mapping to identify the bottlenecks and make the system efficient. Likewise, the manufacturer was recommended to utilize the performance analysis plot of other SDPs, identify the requisite SDOs to improve and accordingly devise the improvement strategies.

Table 2.3.9 Fuzzy Synthetic Extents, weights and normalized weights of SDOs

OIM	FSEs (m_i^-, m_i, m_i^+)	Weights	NW	OIB	FSEs (m_i^-, m_i, m_i^+)	Weights	NW	OIS	FSEs (m_i^-, m_i, m_i^+)	Weights	NW
PPQ	(0.010,0.017,0.037)	0.0000	0.0000	ISE	(0.060,0.112,0.222)	0.1200	0.0365	ISS	(0.071,0.143,0.302)	0.1580	0.0207
IAP	(0.014,0.029,0.061)	0.0040	0.0023	IRP	(0.061,0.115,0.222)	0.1220	0.0371	ISC	(0.068,0.148,0.304)	0.1610	0.0211
ISR	(0.024,0.046,0.104)	0.0480	0.0271	REI	(0.038,0.072,0.152)	0.0830	0.0252	RPR	(0.056,0.120,0.254)	0.1370	0.0179
PPS	(0.044,0.086,0.180)	0.0970	0.0548	ISD	(0.014,0.029,0.062)	0.0020	0.0006	EPM	(0.023,0.042,0.103)	0.0280	0.0037
ESF	(0.058,0.113,0.226)	0.1190	0.0672	RBR	(0.057,0.109,0.211)	0.1180	0.0359	IBM	(0.079,0.171,0.335)	0.1780	0.0233
ICS	(0.050,0.099,0.202)	0.1080	0.0610	ISCt	(0.044,0.085,0.165)	0.0950	0.0289	IBI	(0.024,0.043,0.106)	0.0310	0.0041
INR	(0.049,0.098,0.196)	0.1070	0.0605	ICR	(0.011,0.017,0.037)	0.0000	0.0000	ICO	(0.044,0.097,0.208)	0.1130	0.0148
IRI	(0.048,0.099,0.193)	0.1080	0.0610	IRS	(0.023,0.047,0.098)	0.0430	0.0131	RIM	(0.029,0.065,0.142)	0.0660	0.0086
ICM	(0.042,0.085,0.171)	0.0950	0.0537	IKD	(0.019,0.040,0.079)	0.0240	0.0073	IRL	(0.022,0.043,0.096)	0.0200	0.0026
RSC	(0.010,0.017,0.035)	0.0000	0.0000	IWM	(0.047,0.092,0.179)	0.1020	0.0310	ICE	(0.017,0.034,0.069)	0.0000	0.0000
EFC	(0.023,0.046,0.099)	0.0450	0.0254	IGC	(0.037,0.075,0.146)	0.0830	0.0252	IPC	(0.039,0.093,0.199)	0.1070	0.0140
IAW	(0.019,0.040,0.082)	0.0290	0.0164	BSP	(0.040,0.082,0.155)	0.0910	0.0277				
SREp	(0.046,0.096,0.181)	0.1040	0.0588	ITO	(0.010,0.017,0.032)	0.0000	0.0000				
ICMf	(0.035,0.075,0.152)	0.0850	0.0480	ISMg	(0.053,0.107,0.194)	0.1150	0.0350				
IPS	(0.023,0.052,0.105)	0.0510	0.0288								

Table 2.3.10 Weighted APR of supplier 5 in the along the past timeline

SDOs	CFT 'A'	CFT 'B'	CFT 'C'	APRs	NFSEs	NAPRs
ESF	(5,6.5,8)	(3,5,7)	(5,6.5,8)	(4.33,6.00,7.67)	(0.01,0.06,0.23)	(0.06,0.36,1.73)
ICS	(3,5,7)	(5,6.5,8)	(5,6.5,8)	(4.33,6.00,7.67)	(0.01,0.05,0.20)	(0.05,0.32,1.55)
IRI	(3,5,7)	(3,5,7)	(5,6.5,8)	(3.67,5.50,7.33)	(0.01,0.05,0.19)	(0.04,0.29,1.42)
INR	(5,6.5,8)	(3,5,7)	(5,6.5,8)	(4.33,6.00,7.67)	(0.01,0.05,0.20)	(0.05,0.31,1.50)
SREp	(5,6.5,8)	(5,6.5,8)	(7,8,9)	(5.67,7.00,8.33)	(0.01,0.05,0.18)	(0.06,0.36,1.51)
PPS	(5,6.5,8)	(5,6.5,8)	(7,8,9)	(5.67,7.00,8.33)	(0.01,0.05,0.18)	(0.06,0.32,1.50)
ICM	(7,8,9)	(5,6.5,8)	(5,6.5,8)	(5.67,7.00,8.33)	(0.01,0.05,0.17)	(0.06,0.32,1.43)
ICMf	(7,8,9)	(7,8,9)	(7,8,9)	(7.00,8.00,9.00)	(0.01,0.04,0.15)	(0.06,0.32,1.37)
IRP	(5,6.5,8)	(5,6.5,8)	(7,8,9)	(5.67,7.00,8.33)	(0.01,0.03,0.12)	(0.06,0.21,1.04)
ISE	(2,3.5,5)	(2,3.5,5)	(3,5,7)	(2.33,4.00,5.67)	(0.01,0.03,0.12)	(0.02,0.12,0.71)
RBR	(7,8,9)	(5,6.5,8)	(7,8,9)	(6.33,7.50,8.67)	(0.01,0.03,0.12)	(0.06,0.21,1.03)
ISMg	(7,8,9)	(5,6.5,8)	(7,8,9)	(6.33,7.50,8.67)	(0.01,0.03,0.11)	(0.05,0.21,0.94)
IWM	(3,5,7)	(3,5,7)	(5,6.5,8)	(3.67,5.50,7.33)	(0.01,0.02,0.10)	(0.03,0.13,0.74)
ISCt	(3,5,7)	(5,6.5,8)	(5,6.5,8)	(4.33,6.00,7.67)	(0.01,0.02,0.09)	(0.03,0.13,0.71)
IPS	(5,6.5,8)	(5,6.5,8)	(7,8,9)	(5.67,7.00,8.33)	(0.01,0.03,0.10)	(0.03,0.19,0.83)
BSP	(5,6.5,8)	(3,5,7)	(3,5,7)	(3.67,5.50,7.33)	(0.01,0.02,0.09)	(0.02,0.12,0.64)
ISR	(5,6.5,8)	(5,6.5,8)	(7,8,9)	(5.67,7.00,8.33)	(0.01,0.02,0.10)	(0.03,0.17,0.87)
EFC	(5,6.5,8)	(5,6.5,8)	(5,6.5,8)	(5.00,6.50,8.00)	(0.01,0.01,0.02)	(0.03,0.07,0.19)
REI	(5,6.5,8)	(5,6.5,8)	(7,8,9)	(5.67,7.00,8.33)	(0.01,0.02,0.09)	(0.03,0.13,0.71)
IGC	(5,6.5,8)	(5,6.5,8)	(7,8,9)	(5.67,7.00,8.33)	(0.01,0.01,0.02)	(0.03,0.08,0.19)
IBM	(5,6.5,8)	(3,5,7)	(3,5,7)	(3.67,5.50,7.33)	(0.01,0.04,0.12)	(0.03,0.19,0.85)
ISC	(7,8,9)	(5,6.5,8)	(5,6.5,8)	(5.67,7.00,8.33)	(0.01,0.02,0.04)	(0.05,0.12,0.30)
ISS	(5,6.5,8)	(5,6.5)	8,7,8,9)	(5.67,7.00,8.33)	(0.01,0.02,0.04)	(0.05,0.12,0.30)
					(0.20,0.75,2.78)	(1.01,4.81,22.05)
					Weighted APR	(4.96,6.45,7.92)

SDOs: Supplier Development Outcomes; CFT: Cross Functional Team; APRs: Average Performance Ratings; NFSEs: Normalized Fuzzy Synthetic Extents; NAPRs: Normalized Average Performance Ratings

Table 2.3.11 Performance grades of SDPs running at the suppliers along the timeline

Grade	S1 Performance			S2 Performance			S3 Performance			S4 Performance			S5 Performance		
	Past	Present	Future	Past	Present	Future	Past	Present	Future	Past	Present	Future	Past	Present	Future
A Grade	7.211	2.557	**1.349**	8.969	4.950	3.426	8.787	4.274	4.100	8.287	4.842	3.313	3.559	3.282	3.313
B Grade	6.592	**2.469**	1.973	8.224	4.256	**2.891**	8.052	3.658	**3.454**	7.541	4.165	**2.811**	**2.968**	**2.797**	**2.811**
C Grade	**6.251**	3.537	3.695	7.586	**4.074**	3.295	7.439	**3.723**	3.525	6.938	**4.028**	3.287	3.266	3.300	3.287
D Grade	6.534	5.189	5.605	**7.448**	4.804	4.621	**7.337**	4.727	4.574	**6.884**	4.807	4.659	4.530	4.686	4.659
E Grade	7.117	6.556	7.070	7.692	5.761	5.871	7.612	5.827	5.705	7.217	5.789	5.927	5.759	5.959	5.927

(Note: The shaded cells indicate the obtained lowest Euclidian distance measures from the predefined performance levels)

Further, the company was suggested to redistribute its investments among the SDPs and along the SDOs at micro level. Since, the SDP at S1 is expected to keep going well, now the manufacturer can redistribute its portion of investments and resources allocated to SDP at S1 in developing other key suppliers accordingly. Specifically, the investments can be directed to the SDP running at S5, as it is expected to perform at the same level. Just because an SDP at S5 is not improving it is not advisable to decide that the SDP at S5 has to be cancelled. Rather the manufacturer was recommended to look for possible extraneous influences on SDP at S5. However, the manufacturer was also cautioned it should not happen that development costs exceed the costs of switching the supplier or acquiring supplier's technology. Since these are strategic decisions, before arriving at any conclusion there must be proper evidence collected from all perspectives. Further, by observing the performance analysis plot of all the SDPs and the corresponding SDOs at a micro level, the manufacturer can draw precise plan of actions for continuous performance improvement of SDPs. The manufacturer was asked to record the performance data of various SDPs over a period of time as it would be helpful for the manufacturer in extracting the much more information about the characteristic nature of its suppliers. Specifically, the manufacturer can get to know which supplier is consistent, which supplier is good at what and so on and so forth. Although the current study tried to highlight the important aspects of SDPs and propose an approach to assist a manufacturer to effectively measure, monitor and improve the performance of SDPs, there are certain drawbacks in the study. The possible interactions among the SDOs are not accounted in the study. The suggested SDOs in the study are limited to the perspectives of a manufacturer, supplier and both however, the SDOs could have considered social, economic and environmental perspectives. The methodology could have accounted the practically achievable limits set for the SDOs.

However, these limits can be recorded in practice by benchmarking a best performing SDP. So, the current study can be extended by integrating with a benchmarking approach.

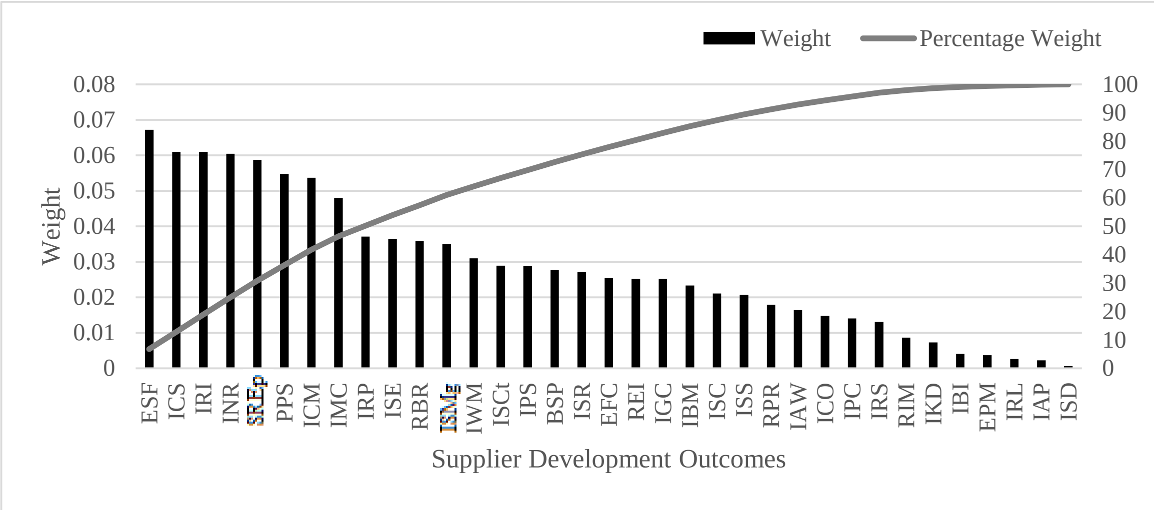
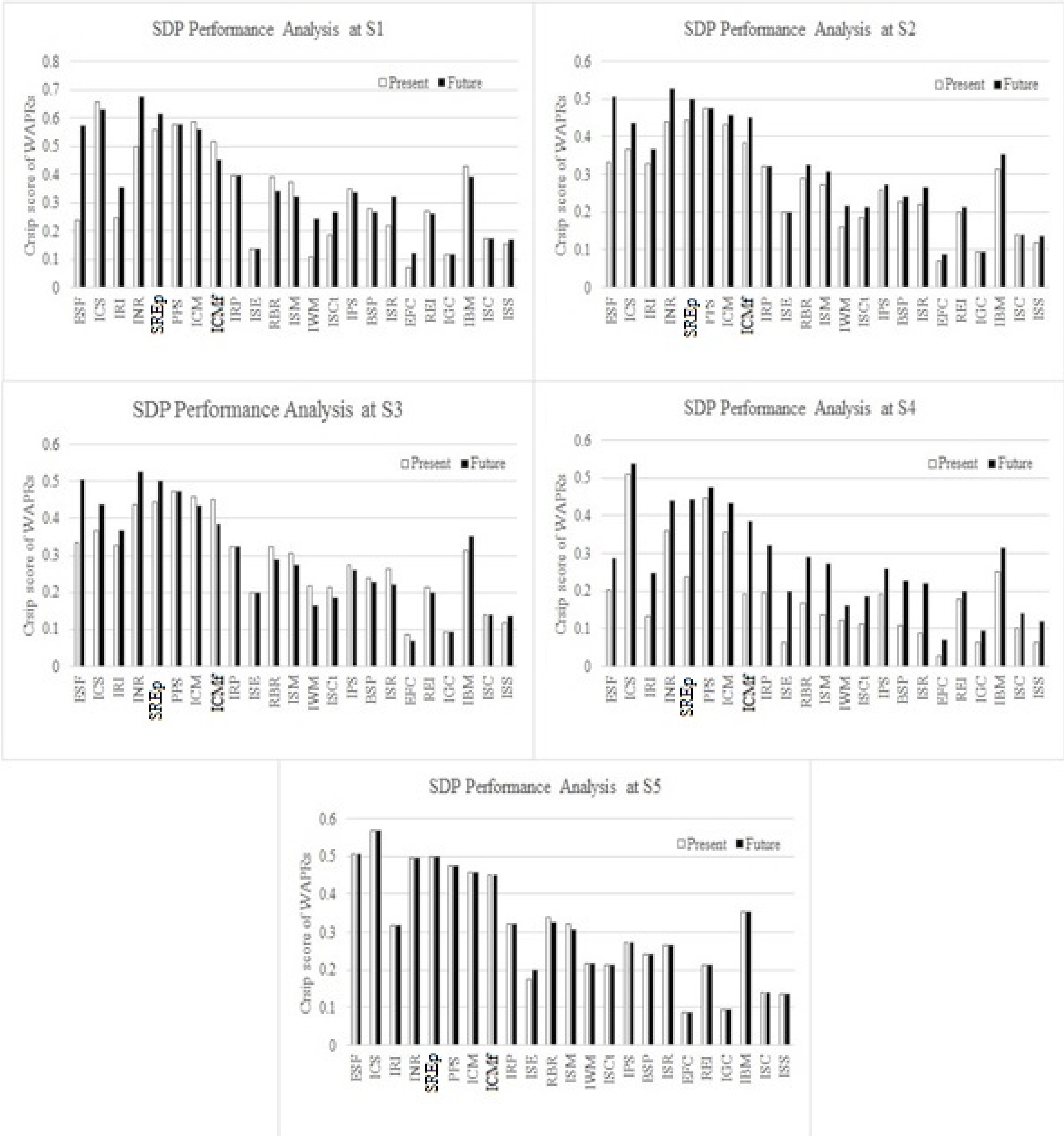


Figure 2.3.2 Pareto analysis to get significant SDOs influencing SDPs for the case company



Note: S1, S2, S3, S4 and S5 are the Suppliers

Figure 2.3.3 Performance analysis of SDPs along the significant SDOs at various suppliers

2.3.6 Sectional summary

The SDPs are the manufacturers' initiatives which involve certain investments and resources while returning back the potential competitive advantages. In order to direct these supplier specific efforts effectively and efficiently, the manufacturers have to ensure that SDPs are fulfilling the stakeholders' interests, analyze the performance levels of SDPs, track the evolution of SDPs and timely redistribute their investments and resources among the SDPs. Thus in the current study, the generic lists of SDOs in the interest of manufacturer, supplier and both in common are considered in order to ensure that the SDPs are fulfilling the stakeholders' interests. Then a methodology has been proposed for periodically analyzing the performance of SDPs on the basis of identified SDOs. By applying this approach, a manufacturer can get to know the level at which the SDPs are running and can make sure that the investments made at right time and in the right SDPs. The said approach also helps a manufacturer to precisely find out the SDOs on which it has to concentrate on a micro level. By timing the practice of proposed approach in analyzing the performances of SDPs, a manufacturer can have the dynamics of SDPs recorded at a micro level and can improve the manufacturer's knowledge about the suppliers. Further, the practice of proposed approach is simplified through an application program developed in MATLAB 2013b. It promptly provides the distribution of measured performance indices of the SDPs and their associated grading over a period of time. It also gives out the performance analysis plots of the SDPs along the SDOs. These results help a manufacturer to quickly visualize and exactly identify the areas of improvement in the SDPs. It has been tried in a practical case situation and was found to be very useful for a manufacturer. The section, hence, aims to revolutionize the way in which manufacturer-supplier relationships can flourish and how SDPs can be used as references to improve the dynamics.

Chapter 3

Preferred Customer Concept

3 Sectional outline of preferred customer concept

This chapter exclusively follow up on the concept of preferred customer mainly along two sections. The section 3.1 discusses about the analysis of preferred customer enablers and the section 3.2 presents the approach for measuring the preferred customer status.

3.1 Sectional abstract to the analysis of preferred customer enablers

The purpose of the study in this section is to identify, rank, classify and establish the structural relationships between the Preferred Customer Enablers (PCEs). This analysis would assist a manufacturer in selectively exercising the PCEs and effectively run-through the concept of reverse marketing in the buyer-supplier relationships. In this regard, the Interpretive Structure modelling (ISM) and Fuzzy Matriced' Impacts Croisés Appliquée á un Classement (FMICMAC) methods are used to analyze and structurally relate the PCEs for Indian automotive component manufacturing industry. Furthermore, the structural relationships among the PCEs were confirmed by applying a Student's t-test. The main findings to ponder from the study are, the classification of PCEs through driver dependence diagrams, structural digraphs of PCEs and statistical significance of the relationships between the PCEs. Further, certain PCEs (under supplier interest and common interest domains) were recommended in the Indian manufacturing environment to broadly control and monitor for achieving the Preferred Customer Status (PCS). The current study provides certain basis for a manufacturer to selectively emphasize and monitor the right PCEs and in turn effectively achieve the PCS from its key suppliers. But, the findings from the current analysis are more applicable in the context of Indian automotive component manufacturing industry. Nonetheless, the similar analysis can be also be extended for other industries and explore the specificities. Under managerial implications: the outcomes from the methodology would provide a basis for a manufacturer to develop the right strategies to become a preferred supply chain partner. To highlight the originality: even though the concept of PCS or reverse marketing can make remarkable impact on the business practices, it has been an ignored topic of research and its practice has been passively prophesied. In this regard, the current study could be a worthy addition towards the practice of preferred customer concept.

3.1.1 Introduction to the analysis of preferred customer enablers

In the present manufacturing business environments, the key suppliers are functioning along multiple supply chain networks that are competing to provide the best of the products/ services. Hence, now-a-days the manufacturers are actively focusing on relationship based strategies and supplier specific strategies in order to have best suppliers to contribute in the value addition process (Sunil Kumar and Routroy, 2015; and Hesping and Schiele, 2015). Almost every manufacturer is inclined towards having the best supply chain partners so as to responsively qualify and win in the ever increasing competition. Besides this manufacturer's inclination, on the other hand most of the suppliers are also inherently extending the privilege of PCS to few of their manufacturing-customers and are endeavoring to favorably associate with them. In this regard, Bemelmans et al. (2015) also mentioned that although the suppliers are expected to treat their manufacturing-customers equally, some are given more importance than the others. This aspect of suppliers preferential attitude towards few of their manufacturing-customers has been introduced as the concept of relational attractiveness of the customer (Tóth et al., 2015). Although suppliers do not display their biasness with few of its manufacturing-customers, nonetheless they are favorably disposed to their Preferred Customers (PCs) when they have to prioritize their relationships.

Manufacturer as a PC of a supplier, acquire flexibility in response to end manufacturing-customers' requirements (Williamson, 1991); have early access to supplier innovation and support in the research and development programs (Carter et al., 2007; and Myers and Cheung, 2008); relatively enjoy better quality products (Nollet et al., 2012); earn improved availability of products, services and resources (Steinle and Schiele, 2008; and Nollet et al., 2012); get price benefits (Myers and Cheung, 2008; Nollet et al., 2012; Schiele, Calvi, et al., 2012 and Schiele, Veldman, et al., 2012); have prioritized services (Schieritz and Grobler, 2003); achieve faster transactions and on time deliveries (Ballou et al., 2000; Nollet et al., 2012); receive support in the sourcing process (Nollet et al., 2012); and reduced risk even with the increasing supplier dependency (Schiele and Vos, 2015). Since most of the markets are open and consist of competitive manufacturers, now the discernment also lies on the key suppliers' end to select a preferred partner in view of their own strategic advantages (Schiele, Veldman, et al., 2012; and Steinle and Schiele, 2008). Tóth et al. (2015) also mentioned that suppliers base their intentions and interactions in view of possible future business opportunities while working with their manufacturing-customers. So, lack of PCS may cause increased uncertainties and shortcomings in the manufacturer's supply management. Some of the negative effects of not being a PC are, a manufacturer relatively must follow up and wait for its orders to be processed (which increases a manufacturer costs); required supplies may not be preferentially designed and developed on time, at low cost, and with better quality; targets set in the interest of manufacturer's customers may not be carefully understood and fulfilled; requisite changes may not be incorporated and complied as required; post sale services may not be much receptive; and most importantly, suppliers may not give careful consideration about the intensity of loss incurred at the manufacturer's end due to the supply uncertainties (Schieritz and Grobler, 2003; and Hüttinger et al., 2012). Most of the manufacturers being in this setup, resort to live with by minimizing the effects (which is easier said than done), search for better conditions (which is expensive as well as time consuming before a healthy relationship is established and maintained) and/ or develop their relationships with the existing suppliers to become a PC (Routroy and Pradhan, 2013). A proactive manufacturer would certainly choose an easier and less expensive option of becoming a PC before trying with other options.

Further, in the case of developing countries where often suppliers' bargaining power is less, the suppliers' contributions are not greatly appreciated; compliance to requirements are not adeptly derived; suppliers are perceived as economic burden; and at times they are deferred and disallowed. But, the increased competition in disguise is favoring the best suppliers along the Manufacturing Supply Chains (MSCs), as now the manufacturers have to competitively offer strategic importance to the suppliers and even develop if required. As the demand for best of the suppliers (who are strategic and critical to the manufacturers) is growing, a manufacturer is urged to be active in achieving PCS. If a manufacturer is an inactive agent, then some of its competitors would be ahead in developing preferential relationships with the best suppliers. Moreover, with the scarcity of good suppliers, a manufacturer has to establish preferential relationships in view of meeting its long term objectives (Nollet et al., 2012). Having stated the above reasons, it is essential for a manufacturer to become a PC for its key suppliers so as to build more competitive and profitable supply chain. For becoming a PC of a supplier, a manufacturer has to possess certain attractive features and fulfill requisite supplier's interests. A manufacturer having the said attractive features and fulfilling the supplier's interests would enable it to become PC of a supplier and hence, they are called as preferred customer enablers. Although, researchers have pointed out various PCEs in their studies, there is no exclusive analytical study conducted in identifying, ranking, and classifying them for a manufacturer's assistance. Also, there is no study reported in the literature to examine the interdependencies between the PCEs which is crucial for devising the right PC strategies. Hence, in current study, various PCEs were identified and analyzed to assist a manufacturer in drawing productive directions for exercising the right PCEs to become a PC.

3.1.2 Literature review on the PCEs

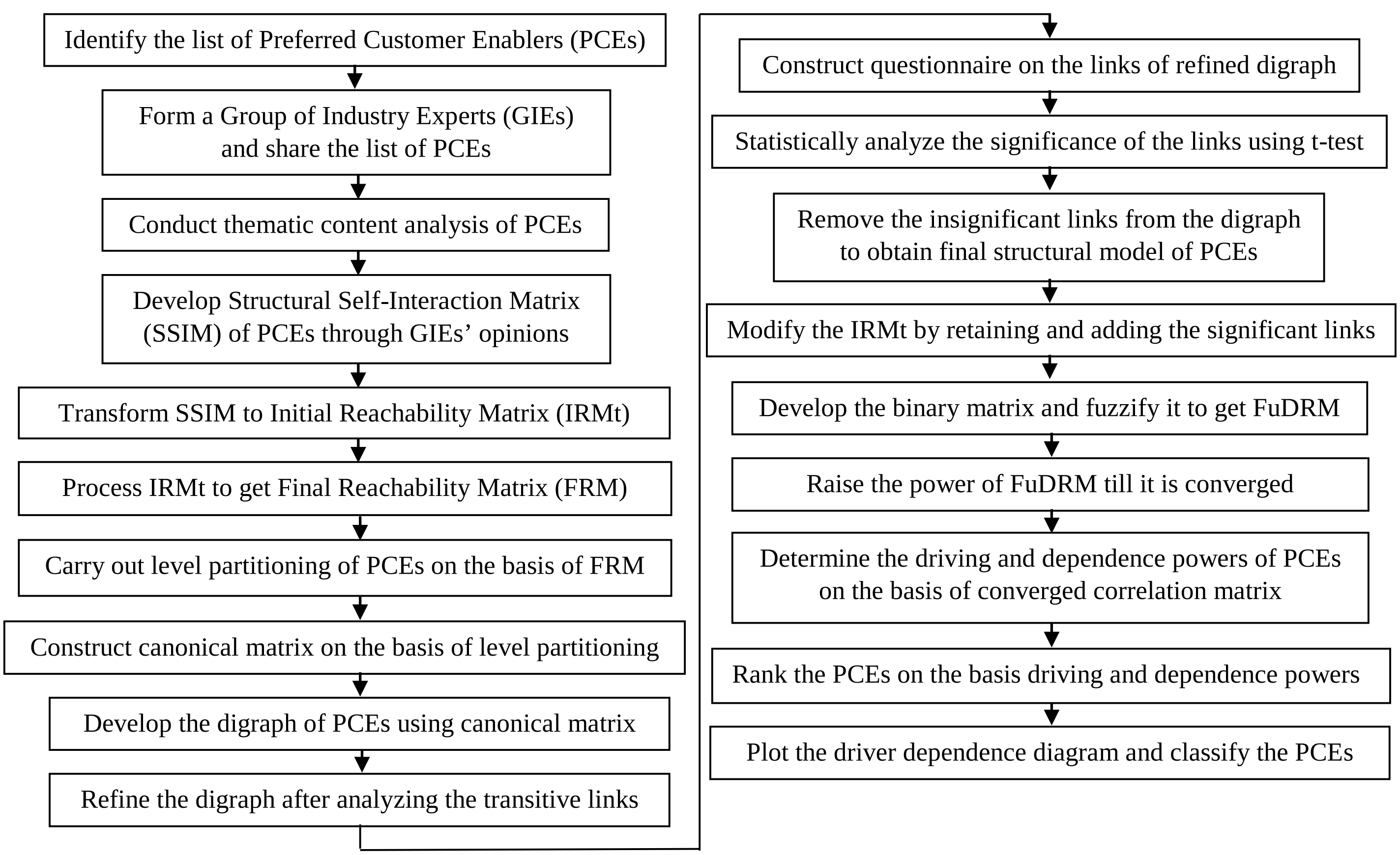
Although numerous strategies are made for influencing the suppliers' to improve support and performance, applying the concept of PCS further facilitates and positions a manufacturer to receive preferential treatment and unconditional support in the value addition process. If a manufacturer wants to become a PC of its suppliers, it has to be attractive in showcasing itself compared to its competitors and provide enough evidence for the suppliers to achieve PCS (Schiele, Calvi, et al., 2012). Manufacturers should embrace the concept of reverse marketing approach and become situated as PCs to the suppliers (Schiele and Vos, 2015). Even from supply side, the suppliers tend to be evaluative in their customer relationships and preferentially associate with them for their own business welfare (Nollet et al., 2012). Moreover, there has been a lot of change in the approaches and roles played by the suppliers as well as manufacturers along the supply chains. As manufacturers are increasingly becoming vertically integrated, now they have to dependent more on their suppliers for their contributions in achieving the competitive advantages. Due to this dependency, a manufacturer has to increasingly focus on managing the flows to occur from not only through itself but also along its suppliers. In this process, manufacturers often choose to develop their key suppliers who are falling short off in meeting their performance requirements through supplier development programs (Routroy and Sunil Kumar, 2014). In all through these endeavors, the preferential relationships extended by the respective partners reduce the number of issues to be handled and enhance the satisfaction levels beyond the expectations. Although, the concept of PC was introduced back in 1970's by Hottenstein (1970), still there has not been sufficient research carried out on this topic. However, recently few researchers have started contributing by exploring more insights and laying guidelines for both research and practice. The following discussion presents the important excerpts from the research studies: Steinle and Schiele (2008) portrayed the limitations of global sourcing and stressed that the percentage increase in it may not necessarily improve competitiveness. They argued that attaining the PC perception by a local supplier who is closely located is relatively easier than that of the foreign suppliers who are remotely located. Schiele et al. (2011) analyzed an important aspect regarding supplier pricing behavior. They state that the increased learning innovative capabilities may induce the suppliers to quote unfair prices, but PCS would help the buyer to reverse the tendency and derive benevolent pricing. They suggested that by implementing PC policy, improved conditions to innovate can be prevailed along the suppliers. Schiele, Veldman et al. (2012) explored the counter intuitive inversion of the classical marketing approach (i.e. manufacturers competing for suppliers) and offered certain insights for the firms to achieve PCS. They proposed a cyclic model of preferred customership consisting of three stages namely customer attractiveness, supplier satisfaction and PCS in the context of social exchange theory. Nollet et al. (2012) suggested a four step model (i.e. initial attraction, performance, engagement and sustainability) and specific tactics for the firms to achieve and maintain their PCS from the suppliers. Their study highlighted the systematic step by step process to be adopted by the manufacturers in achieving PCS. Baxter (2012) studied the supplier perspective on a buyer's financial attractiveness and its influence on a supplier's behavior and actions. A model was developed by considering buyer's financial attractiveness, supplier satisfaction, supplier commitment and supplier's preferential treatment. Their study revealed the importance of managing supplier's perceptions by the buyer in order to derive preferential investments of resources from its suppliers. Ellis et al. (2012) addressed the very important research gap, how a buyer can access supplier innovation by becoming a PC. They developed a structural model addressing the length of relationship, supplier involvement, relationship reliability, and share of sales through PC treatment for accessing a supplier's technology. The results obtained by them were quite interesting, the share of sales had no effect on PCS and the buyers seeking innovations from suppliers had to manage supplier's perceptions. Hüttinger et al. (2012) conducted a literature review on the drivers, customer attractiveness, supplier satisfaction and PCS. They have developed a conceptual basis, established the reasons why suppliers offer preferential treatment to their buyers and have paved the strong foundation for further research. Pulles et al. (2015) have advocated two concepts namely, "customer attractiveness" and "supplier satisfaction" for a manufacturer to follow-up in becoming a PC. They found that the influence of customer attractiveness in deriving best of the resources from the suppliers is mediated by supplier satisfaction. Bemelmans et al. (2015) focused on exploring the antecedents (specifically on a supplier's perception about a manufacturer as a matured in supplier relationship management) and the impact of PCS. They found that achieving PCS is beneficial for a manufacturer while collaborating with a supplier and leads to improved manufacturer's satisfaction. Schiele and Vos (2015) justly highlighted the serious dilemma being spread that, a manufacturer has to experience supplier obstructionism due to increase in the supplier dependency. In contrary to this, they clearly demonstrated that when there are close ties in between the manufacturer-supplier, a manufacturer as a PC can absolutely take the risk of supplier dependency.

From time immemorial, it has been proven that early into the market advantage puts a manufacturer ahead of many even if it is relatively lacking in certain aspects. Similarly, better is the chance of winning the competition for those manufacturers who are ahead of their competitors in establishing and developing preferential relationships with the leading suppliers in the industry. Moreover, the preferential relationships awarded by the suppliers are competitive; if a supplier finds a better alternative customer, the preferences awarded by that supplier may be changed (Nollet et al., 2012; Schiele, Veldman, et al., 2012). Although PCS can have tremendous impact on buyer-supplier exchanges and ultimately on businesses, researchers have expressed that the concept of PCS was not given much attention. There is no enough information for the firms on how to manage their status from suppliers' perspective (Baxter, 2012; Hüttinger et al., 2012; Nollet et al., 2012; Schiele, Veldman, et al., 2012; and Pulles et al. 2015). Specifically, there are no objective studies conducted to identify and analyze the PCEs so as to assist a manufacturer in achieving the PCS. Thus, various PCEs under different domains (namely manufacturer's characteristic features, supplier specific interests and common interests of both supplier and manufacturer) were identified through literature review, brainstorming, and discussions held with the academic researchers and industry experts (Tables 2-4 show the lists of PCEs along with the extracted support from the literature). Further, a research methodology has been proposed and applied to investigate how the manufacturers can achieve PCS from their key suppliers. The methodology is aimed at exploring structural relationships between the PCEs and statistically confirming the explored relationships. The results obtained would assist a manufacturer to visualize the relationships between the PCEs and devise requisite strategies to become PC of a supplier.

3.1.3 Methodology for analyzing the PCEs

The proposed methodology in this study starts with the application of Interpretive Structural Modelling (ISM). It is an effective group decision method proposed by Warfield (1974) to establish the intricate relationship between the elements in a complex system. It has been used as a qualitative tool by various researchers to draw the order and direct the relationships among the elements in the form of graphical presentation (Kumar and Routroy, 2014; Routroy and Kumar Pradhan, 2014; Sage, 1977) This graphical presentation obtained through ISM has been regarded as a consensual mind map of the experts associated with the system, who have thorough knowledge about systems' designs, plans and operations. Most of the researchers who used ISM in addressing their research problems have expressed in their conclusions that the results are context specific and they cannot be generalized. Also, many suggested that their research work can be further extended in order to statistically confirm and generalize their results. In this connection, researchers have started upgrading ISM as Total ISM (TISM) and integrating it with statistical validations there by confirming the structural relationships (Nasim, 2011; Sushil, 2012; and Yadav, 2014). Taking the TISM as reference, a step by step procedure of improved ISM-FMICMAC analysis has been proposed in the current study and it is detailed in the following section.

Figure 3.1.1 Improved Interpretive Structural Modeling-Fuzzy MICMAC analysis



3.1.3.1 Improved Interpretive Structural Modelling-Fuzzy MICMAC analysis

The step by step procedural details of the proposed methodology are mentioned below and is also shown as a flowchart in Figure 3.1.1.

Step 1: Identify a list of PCEs which would facilitate a manufacturer to become a PC to its key suppliers through literature review, brainstorming sessions and discussions with the academic researchers and industry experts.

Step 2: Consult a group of experts drawn from an industry and academics who are having sufficiently large experience and in depth knowledge in the said field of study. This group of experts' judgements form a basis for identifying the relevant PCEs and conducting the thematic content analysis. Larger the number of experts considered for the analysis, better will be the accuracy in capturing the real world scenario. However, the discretion for number of experts to be approached must be based on the variability in the opinions collected. It is essential to have larger data sets collected if there is no essential consensus in the experts' opinions.

Step 3: Conduct a thematic content analysis of PCEs to broadly define the domain of the PCEs (obtained in the step 1) on the basis of experts' remarks. In the said analysis, the experts are asked to ascribe the PCEs under different domains. Further, the PCEs are grouped under different domains based on the obtained percentage of opinions. For conducting the thematic content analysis, larger number of experts' opinions can be collected as it should not overly exert the experts and time taking.

Step 4: Form a focused group of experts for analyzing the PCEs and developing the structural relationship digraphs of PCEs along their respective domain. The following procedural steps of ISM method are executed for conducting the said analysis of PCEs and establishing the structural relationships in between the PCEs.

Step 4.1: Develop a Structural Self-Interaction Matrix (SSIM) by drawing contextual relationships among the PCEs on the basis of experts' opinions. Four symbols (A: PCE 'j' leads to PCE 'i'; V: PCE 'i' leads to PCE 'j'; X: PCE 'i' leads to PCE 'j' and PCE 'j' leads to PCE 'i' and O: No relationship between PCE 'i' and PCE 'j') are used for obtaining the type of the relation that exists between the PCEs ('i' and 'j'). The type of relationship in between any two PCEs of SSIM must be ascertained by fixing a threshold value for the percentage of experts' opinions obtained from the focused group under the abovementioned four types of relations. As mentioned in the step 2, the discretion for number of experts approached can be made on the basis of variability in the opinions obtained at this juncture from the focused group and in the step 3.

Step 4.2: Develop the Initial Reachability Matrix (IRMt) by converting SSIM into a binary matrix, by substituting V, A, X and O with 1 and 0. The substitutions are made with 1's and 0' as per the following rules:

- If the (i, j) entry in the SSIM is V, then the (i, j) entry in the IRMt becomes 1 and the (j, i) entry becomes 0.
- If the (i, j) entry in the SSIM is A, then the (i, j) entry in the IRMt becomes 0 and the (j, i) entry becomes 1.
- If the (i, j) entry in the SSIM is X, then the (i, j) entry in the IRMt becomes 1 and the (j, i) entry also becomes 1.

- If the (i, j) entry in the SSIM is 0, then the (i, j) entry in the IRMt becomes 0 and the (j, i) entry also becomes 0.

Step 4.3: Develop the Final Reachability Matrix (FRM) from IRMt accounting the transitivity among the contextual relations of PCEs. Transitivity in the relationship is determined as follows: if PCE "i" is related to PCE 'j' and PCE 'j' is related to PCE 'k', then PCE 'i' is related to PCE 'k'. Then the (i, k) entry in the FRM becomes 1*.

Step 4.4: Carry out the level partitioning of PCEs by developing the reachability and antecedent sets for each PCE on the basis of FRM. The reachability set of a PCE contains the PCE itself and the other PCEs which it may reach. Whereas, the antecedent set of a PCE contains the PCE itself and other PCEs which may reach it. Obtain the intersection set of a PCE by taking out the common relations in between the reachability and antecedent sets. The PCEs for which the reachability and intersection sets are same will occupy the top-level in the structural hierarchy of the digraphs. The top-level PCEs are separated out from the initial set of PCEs and then the process is repeated until all the PCEs are assigned to a level.

Step 4.5: Develop a Lower Triangular Matrix (LTM) or a canonical matrix from the level partitions obtained in the previous step. It is just another form of FRM in which PCEs are positioned and clustered according to the level of partition.

Step 5: Develop a structural directed graph (called as digraph) on the basis of entries in the LTM obtained in the step 4.5. If a relationship (directly or indirectly) exists between PCE 'i' and PCE 'j' then it is shown by an arrow (i.e. link) pointing from PCE 'i' to PCE ‘j’. The development of digraph should made on the basis of critical direct links which can utmost simultaneously define the associated relationships between the other PCEs. Further, the digraph can be added with other identified transitive links (obtained in FRM) which are perceived to be significant enough to be established as direct relationships. For differentiation, the direct link between the PCEs must be denoted by a continuous line whereas the transitive link by a dotted line.

Step 6: Construct a questionnaire on the links of the digraph obtained in the previous step and collect the responses related to the degree of influence between the PCEs on a likert scale of 1 to 5 from a sample of experts. For example, if PCE1 is linked with PCE2 in the diagraph, then the framed question should be “PCE1 leads to PCE2”.

Step 7: Statistically analyze the collected experts’ responses (obtained in the previous step) through t-test for statistical verification of the links.

Step 8: Modify the IRMt to obtain the Significant IRMt (SIRM) by retaining and adding the significant links and dropping the insignificant links on the basis of significance values obtained after conducting the t-test in the previous step.

Step 9: Construct the Binary Direct Relationship Matrix (BDRM) of PCEs by replacing all the diagonal 1’s with 0’s from the obtained SIRM in the previous step. Then, the BDRM must be fuzzified to obtain Fuzzy Direct Relationship Matrix (FuDRM) by again consulting the same group of experts formed in the step 2 by asking them to rate the degree of influence a PCE would have on another using Table 1 as a reference.

Step 10: Raise the power of FuDRM by matrix multiplication (rule: C = max k {min (a_{ik}, b_{kj})} where A = [a_{ik}], B = [b_{kj}]) till it is converged. The convergence point can be obtained where the driving and dependence powers of PCEs are stabilized or cyclic in their variation with certain periodicity. Determine the driving (row sum) and dependence (column sum) powers on the basis of converged matrix and accordingly ranks the PCEs.

Table 3.1.1 Possible Relationship Strength between PCEs

Dominance of Interaction	No.	Very Low	Low	Medium	High	Very High	Full
Grade	N	NL	L	M	H	VH	F
Value on the Scale	0	0.1	0.3	0.5	0.7	0.9	1

Step 11: Plot the driver dependence diagram (with dependence power along the X-axis and driving power along the Y-axis) to classify the PCEs into four groups by dividing the XY plane into four quadrants depending upon their intensity of powers. This classification would help a manufacturer to develop the strategies for improving its PCS.

The above discussed methodology was coded in MATLAB R2013b to reduce the computational burden on the users. Just with few entries of data, all the procedural steps are executed and the results are generated within no time.

3.1.4 Application process for analyzing the PCEs

In this section, the application process of the proposed methodology is presented by following the step by step procedure detailed in the previous section. As per the above discussed methodology, PCEs were identified through literature review, brain storming sessions and discussions held with the industry experts. Then according to step 2, a group of ninety experts who are highly qualified and experienced in handling the procurement functions from the automotive component manufacturing industry in India were consulted. As per step 3, the list of PCEs obtained in the step 1 were subjected to thematic content analysis, the experts' opinions sought were consensual about the relevancy of the PCEs. The obtained percentage of opinions clearly categorized the PCEs into three domains namely, PCEs in the interest of supplier (see Table 3.1.2), PCEs in the common interest of both supplier and manufacturer (see Table 3.1.3) and manufacturer's characteristic features that a supplier would be interested in (see Table 3.1.4). Although, a manufacturer's characteristic features are important in enabling the PCS of a manufacturer, yet their improvement would be long term objectives. Hence, in the current study, two domains (i.e. PCEs under supplier interest and under common interest) were considered for analysis. As per step 4, a focused group of twenty five experts (who were mostly designated as general managers and heads of procurement departments with a minimum experience of fifteen years) was formed. The research objectives and the steps followed in the proposed methodology were explained to them and their inputs along the process were sought. Most of the discussions during the course of study were carried out mainly through internet, by circulating the soft and hardcopy materials, and through telephonic conversations by seeking their convenient timings. Then, the ISM methodology was applied to develop the digraphs of PCEs under the two chosen domains. Following the step 4.1, SSIMs of PCEs under the two domains were constructed and the experts' opinions regarding the influence of one PCE over the other were collected. In ascertaining the type of relationship in between the PCEs, a threshold value of 70% was fixed. All the types relationships imparted in between the PCEs of SSIMs were supported by more than 70% of experts' opinions. Then, on the basis of SSIMs, the IRMts and FRMs of PCEs were subsequently obtained by following the steps 4.2 and 4.3. Next, the level partitioning of PCEs was carried out and on the basis of these levels, the respective LTMs were developed according to the steps 4.4 and 4.5 (Table 3.1.5 shows the distribution of PCEs along different levels under both supplier and common interest domains). Based on these LTMs, the diagraphs of PCEs under respective domain were constructed. These digraphs were constructed by positioning the PCEs as per the partitioned levels and the order in which they were partitioned. Links between the PCEs in the diagraphs were laid out on the basis of direct links (noted as 1 in the respective LTM of PCEs) as well as the associated transitive links based on the laid direct link. It must be noted that the direct links laid here becomes the critical ones and the basis for establishing all the relationships between the PCEs. Once all the relationships between the PCEs were established through the diagraphs (see Figures 3.1.2a and 3.1.2b), two sets of questionnaires were developed on the basis of links between the PCEs (as discussed in the step 5). In the development of questionnaires, questions regarding the relationships between the PCEs obtained as a result of transitivity were also included to test their direct significance. Here it must be noted that the advantage of using ISM method was, the number of relationships between the PCEs to be tested got enormously reduced (from $12C_2 \times 2$ i.e. 122 to 25 under supplier interest domain and $12C_2 \times 2$ i.e. 122 to 26 under common interest domain). These questionnaires were developed for statistical confirmation of the obtained relationships between the PCEs. These were further sent to a group of thirty procurement experts (Yadav, 2014) with a minimum experience of fifteen years in the Indian automotive component manufacturing companies. The experts were asked to rate the degree to which they agree with the relationship between the linked PCEs on a 1to 5 Likert scale (1 being strongly disagree and 5 being strongly agree). For example, if the relationship between PPO and BEM was to be tested, then the link is represented as PPOBEM and the question asked was, “Prompt payment of outstanding bills leads to business expectancy created by a manufacturer”. The data obtained from the experts were then used to compare with a test mean of 3.5 using the one sample one tailed t-test at a 95% level of confidence. The generalized hypotheses constructed for testing a relationship between the PCEs are shown below.

Question: Does the overall response from the sample of experts regarding the degree of agreement on a relationship between the PCEs of a tested link supersede the test mean?

Hypotheses:

H_o: $\mu_{sample} - \mu_{test} = 0$ (i.e. There is no significant different between the sample mean and test mean)

$H_{1:}$ $\mu_{sample} - \mu_{test} > 0$ (i.e. There is significant different between the sample mean and test mean)

For α level of significance, $P \leq 0.05$ is considered to be significant to reject the null hypothesis. One sample one tailed t test was used for testing the hypotheses since, the direction of difference between two means were to be tested. R 3.1.3 was used to perform the t-test, the observed t-statistics are shown in the Table 3.1.6. Based on the obtained P-value along the tested links, the significant links were accepted while the insignificant ones were rejected. Those links including the transitive ones which were accepted to be significant from the t-test were noted as 1 (indicating the existence of direct relationship between the PCEs) and those which were insignificant were noted as 0 in the respective IRMts to obtain the SIRMs. Further, using these SIRMs, BDRMs were constructed and they were subsequently fuzzified to obtain FuDRMs. Then according to step 10, the power of FuDRMs were raised by matrix multiplication till they are converged (see Figures 3 and 4 for convergence plots). From the converged matrices the driving and dependence powers of PCEs were determined and on the basis of which PCEs were ranked. According to step 11, using the driving and dependence powers of PCEs the driver dependence diagrams of PCEs were plotted (see Figures 5 and 6). The next section presents the details of the results obtained along the steps of the proposed methodology are presented.

3.1.5 Results and discussion

Along the steps of the proposed methodology, the structural diagraphs of PCEs were constructed under the two domains chosen for analysis. These structural relationships between the PCEs were established by taking the qualitative opinions from a focused group of twenty five industry experts. The level partitioning of the PCEs obtained under both the domains are shown in the Table 5. Even though the level partitioning was carried out on the basis of reachability, antecedent and intersection sets of PCEs, indirectly it is implicit that it was carried out on the basis of driving and dependence capabilities of PCEs. Thus, it can be said that those PCEs which occupy at the bottom most level have the highest driving power while those occupied the top most levels have high dependence powers. Based on the levels in which the PCEs were positioned, subsequently a hierarchical structured digraphs were constructed (see Figures 2a and 2b). In order to have sufficient confidence in the established relationships through ISM, the statistical significance of the links were tested using one tailed t-test. For conducting the test, questions on 25 links (22 direct and 3 transitive) from the digraph under supplier interest domain and 26 (21 direct and 5 transitive) links from the digraph under common interest domain were framed. These questionnaire were circulated and data was collected from a sample of experts. The results obtained after conducting the t-test (shown in the Table 6) show that those links whose significance value is greater than 0.05 were rejected. Rejection of a link means there was no sufficient degree of acceptance on the existence of relationship between the connected PCEs from the sample of experts' opinions. Under supplier domain, the links OQF to SOQ and LAA to SAR were rejected while all the transitive links (NBT to RIN, PRM to MIS and RSM to MIS) were accepted. Whereas under common interest domain, the links CAC to BCP and BCM to BSCt were turned out to be insignificant and here also all the transitive links tested were accepted by the experts. In the final part of the methodology, the PCEs were subjected to Fuzzy MICMAC analysis and the PCEs were distributed among the four quadrants of the driver dependence diagrams. The significance of the said four quadrants is discussed in the next section.

Table 3.1.2 PCEs under common interest domain

PCE	Description	Support sought from the literature
MCP	Level of interest and disposition shown in the mutual visits paid by the competent personnel.	(Hüttinger et al., 2012), (Nollet et al., 2012), (Ellegaard and Koch, 2012)
CSV	Level of value and waste generated at both supplier and manufacturer ends.	(Christiansen and Maltz, 2002), (Winter and Lasch, 2011), (Schiele et al., 2011)
TRU	Degree of confidence level built on the transactions.	(Hald et al., 2009), (Dahwa et al., 2013), (Yeniyurt et al., 2014), (Horn et al., 2014)
TMC	Degree of commitment manifested from the top management in materializing the proposed initiatives.	(Schiele, 2010), (Nollet et al., 2012), (SCHIELE et al., 2011), (Horn et al., 2014)
BSC	Responsiveness in calls and responses during planning and execution of the supply chain activities.	(Forker and Stannack, 2000), (Caniëls et al., 2013), (Leuschner et al., 2013)
BCO	Mutual works are timed thoroughly in meeting the customer requirements.	(Winter and Lasch, 2011), (Mortensen, 2012), (Yan and Dooley, 2014)
BCL	Joint efforts and shared responsibilities in between buyer and supplier.	(Park et al., 2010), (Najafi Tavani et al., 2013)
BCM	Communication channels are laid out for essential information exchange in between buyer and supplier.	(Nollet et al., 2012), (Hüttinger et al., 2012), (La Rocca et al., 2012), (Yeniyurt et al., 2014)
BCP	Adherence to the mutually laid out approved plans in fulfilling the customer requirements.	(Ellegaard et al., 2003), (Hoffmann et al., 2013)
BSCt	Commonality brought about in the operating conditions.	(Hüttinger et al., 2012), (Lager and Storm, 2012), (Arroyo-López et al., 2012)
CAC	Certifications and accreditations achieved depict the standards of operations.	(Cox, 2004), (Mwikali and Kavale, 2012), (Arroyo-López et al., 2012)
EMB	Conformance to the ethics and moral values in the business practices.	(Ramsay and Wagner, 2009), (Schiele et al., 2011), (Ellis et al., 2012)
Mutual visits by Competent Personnel (MCP); Cost Savings and Value addition achieved (CSV); Trust (TRU); Top Management Commitment (TMC); Buyer-Supplier Cooperation (BSC); Buyer-Supplier Coordination (BCO); Buyer-Supplier Collaboration (BCL); Buyer-Supplier Communication (BCM); Buyer-Supplier Compliance (BCP); Buyer-Supplier Compatibility (BSCt); Certifications and Accreditation (CAC); Ethical and Moral Business Values (EMB)		

Table 3.1.3 PCEs under manufacturer's characteristic features

PCE	Description	Support sought from the literature
PPO	Manufacturer's timely payments to the services or inputs received from the supplier.	(Chopra and Meindl, 2007), (Jones, 2008)
MIS	Duration for which the manufacturer's inventory is maintained at the supplier site.	(Martínez-de-Albéniz and Simchi-Levi, 2013)
OQF	Ordered quantity and frequency from the manufacturer.	(Xia et al., 2008), (Wee and Widyadana, 2013), (Hu et al., 2013)
SOQ	Parity in the ordered quantity by the manufacturer.	(Ramsay and Wagner, 2009), (Wee and Widyadana, 2013)
LAA	Extent of integrity in the manufacturer's requirements with the supplier's business as a whole.	(Choi et al., 2001), (Trent and Monczka, 2003)
RIN	Level of responsiveness achieved in transferring the returns on supplier's innovation.	(Ramsay and Wagner, 2009), (Narasimhan and Narayanan, 2013), (Yeniyurt et al., 2014), (Wagner and Bode, 2014)
SAR	Mechanisms adopted in acknowledging the supplier's efforts and contributions.	(Dedhia, 1990), (Klassen and Vachon, 2003), (Sucky and Durst, 2013)
PRM	Mechanisms adopted to share profits made and risks incurred from the proposed initiatives.	(Hüttinger et al., 2012), (Routroy and Sunil Kumar, 2014)
RSM	Supportive resource sharing mechanisms offered by the manufacturer.	(Kanda and Deshmukh, 2008), (Yan and Dooley, 2014)
CCM	Conflicts during the contracts are clearly defined well in advance along with the resolutions.	(Cox, 2004), (Dahwa et al., 2013), (Yan and Dooley, 2014)
BEM	Manufacturer's assurance in providing future business opportunities to the supplier.	(Hald et al., 2009), (Mortensen and Arlbjørn, 2012), (Schiele, Veldman, et al., 2012)
NBT	Manufacturer's responsive business processes in promptly carrying out the transactions.	(Cox, 2004), (Steven et al., 2014)

Prompt Payments of Outstanding bills (PPO); Manufacturer's pull on Inventory from Supplier (MIS); Ordered Quantity and Frequency (OQF); Stability in Ordered Quantity (SOQ); Level of Aggregation achieved (LAA); Returns on Innovation (RIN); Supplier Awards and Recognition (SAR); Profit and Risk sharing Mechanism (PRM); Resource Sharing Mechanism (RSM); Contract's design with Conflict Management (CCM); Business Expectancy from the Manufacturer (BEM); Nimble Business Transactions (NBT)

Table 3.1.4 PCEs under supplier interest domain

PCE	Description	Support sought from the literature
PPO	Manufacturer’s timely payments to the services or inputs received from the supplier.	(Chopra and Meindl, 2007), (Jones, 2008)
MIS	Duration for which the manufacturer’s inventory is maintained at the supplier site.	(Martínez-de-Albéniz and Simchi-Levi, 2013)
OQF	Ordered quantity and frequency from the manufacturer.	(Xia et al., 2008), (Wee and Widyadana, 2013), (Hu et al., 2013)
SOQ	Parity in the ordered quantity by the manufacturer.	(Ramsay and Wagner, 2009), (Wee and Widyadana, 2013)
LAA	Extent of integrity in the manufacturer's requirements with the supplier’s business as a whole.	(Choi et al., 2001), (Trent and Monczka, 2003)
RIN	Level of responsiveness achieved in transferring the returns on supplier’s innovation.	(Ramsay and Wagner, 2009), (Narasimhan and Narayanan, 2013), (Yeniyurt et al., 2014), (Wagner and Bode, 2014)
SAR	Mechanisms adopted in acknowledging the supplier's efforts and contributions.	(Dedhia, 1990), (Klassen and Vachon, 2003), (Sucky and Durst, 2013)
PRM	Mechanisms adopted to share profits made and risks incurred from the proposed initiatives.	(Hüttinger et al., 2012), (Routroy and Sunil Kumar, 2014)
RSM	Supportive resource sharing mechanisms offered by the manufacturer.	(Kanda and Deshmukh, 2008), (Yan and Dooley, 2014)
CCM	Conflicts during the contracts are clearly defined well in advance along with the resolutions.	(Cox, 2004), (Dahwa et al., 2013), (Yan and Dooley, 2014)
BEM	Manufacturer's assurance in providing future business opportunities to the supplier.	(Hald et al., 2009), (Mortensen and Arlbjørn, 2012), (Schiele, Veldman, et al., 2012)
NBT	Manufacturer’s responsive business processes in promptly carrying out the transactions.	(Cox, 2004), (Steven et al., 2014)
Prompt Payments of Outstanding bills (PPO); Manufacturer’s pull on Inventory from Supplier (MIS); Ordered Quantity and Frequency (OQF); Stability in Ordered Quantity (SOQ); Level of Aggregation achieved (LAA); Returns on Innovation (RIN); Supplier Awards and Recognition (SAR); Profit and Risk sharing Mechanism (PRM); Resource Sharing Mechanism (RSM); Contract's design with Conflict Management (CCM); Business Expectancy from the Manufacturer (BEM); Nimble Business Transactions (NBT)		

Table 3.1.5 PCEs under manufacturer's characteristic features

PCE	Description	Support sought from the literature
OWC	Capability to win orders and generate further business.	(Fynes and Voss, 2002),(Vieira et al., 2013), (Fawcett and Waller, 2013)
GMS	Ability to grow consistently and increase its market share.	(Song et al., 2012), (Govindarajan and Trimble, 2012), (Hüttinger et al., 2012), (Sullivan et al., 2012)
TMV	Ability to set and achieve targets towards laid out missionary and visionary objectives.	(Caddick and Dale, 1998), (Sommer, 2004)
KBD	Organizational learning initiatives to update knowledge and business skills.	(Ramsay and Wagner, 2009), (Graebner et al., 2010)
CSR	Socially responsible initiatives taken by the manufacturer.	(Duffy et al., 2013), (Pulles et al., 2014)
CPM	Manufacturer's ranking in the industry.	(Mortensen, 2012), (Baxter, 2012), (Nagati and Rebolledo, 2013), (Hüttinger et al., 2012)
GLP	International presence and level of business conducted.	(Johansson and Ronkainen, 2005), (Raizada, 2011), (Lockström and Lei, 2012), (Horn et al., 2014)
BPR	Initiatives taken for advanced business transformations.	(Sommer, 2004), (Hüttinger et al., 2012)
SOL	Strength through the top management's competent leadership.	(Quayle, 2000), (Meehan and Wright, 2011)
FIC	Financial reserves and assets possessed by the manufacturer.	(Ramsay and Wagner, 2009), (Park et al., 2010), (Baxter, 2012), (Hüttinger et al., 2012)
BRV	Trademark valued by the stakeholders along the supply chain.	(Ramsay and Wagner, 2009), (Raizada, 2011), (Nollet et al., 2012)
TEC	Manufacturer's technological capability in procurement, manufacturing and distribution.	(Park et al., 2010), (Hüttinger et al., 2012)

Order Winning Capability (OWC); Growth in the Market Share (GMS); Targets achieved towards Mission and Vision (TMV); Knowledge and Business Skills Development (KBD); Corporate Social Responsibility (CSR); Competitive Position in the Market (CPM); Global Presence (GLP); Business Process Reengineering (BPR); Strength of Leadership (SOL); Financial Capability (FIC); Brand Value (BRV); Technological Capability (TEC)

Table 3.1.6 Level partitioning of PCEs under supplier and common interest domains

Level	Under supplier interest	Level	Under common interest
I	MIS, BEM, NBT	I	CSV, TRU, BCL, EMB
II	PPO, MIS	II	BCO, BCP
III	OQF, SAQ, LAA, CCM	III	BSC, BSCt, CAC
IV	SAR, PRM, SRM	IV	MCP, BCM
		V	TMC

Table 3.1.7 Results obtained after hypotheses testing of links

Observed statistics under supplier interest domain					Observed statistics under common interest domain				
Link	t-value	P-value	Mean	Remark	Link	t-value	P-value	Mean	Remark
MISOQF	5.771	0.000001	4.20	Accept	CSVTRU	9.8932	0	4.4	Accept
BEMMIS	4.7619	0.000025	4.20	Accept	TRUBCL	10.4345	0	4.47	Accept
NBTMIS	2.5878	0.007469	3.87	Accept	BCLEMB	5.8446	0.000001	4.3	Accept
BEMNBT	13.3276	0	4.67	Accept	EMBTRU	4.1766	0.000124	4.17	Accept
PPOBEM	11.5919	0	4.57	Accept	TRUBCO	9.8932	0	4.4	Accept
RINBEM	12.0917	0	4.60	Accept	TRUBSC	11.1542	0	4.53	Accept
NBTRIN	-3.4213	0.999100	2.93	Accept	BCPCSV	8.6978	0	4.5	Accept
RINPPO	3.6121	0.000567	4.03	Accept	BCPTRU	10.1429	0	4.43	Accept
OQFPPO	10.7703	0	4.50	Accept	BCPBCL	5.0374	0.000011	4.2	Accept
LAAPPO	3.8191	0.000326	4.03	Accept	BCPEMB	6.606	0	4.43	Accept
CCMPPO	10.4345	0	4.47	Accept	BCOBCP	10.7703	0	4.5	Accept
CCMRIN	3.2825	0.001343	4.03	Accept	BSCtBCO	3.9543	0.000227	4.07	Accept
OQFSOQ	-9.027	1	2.03	Reject	BSCtBCP	4.5272	0.000047	4.2	Accept
CCMOQF	2.5878	0.007469	3.87	Accept	CACBCP	-9.5697	1	2.5	Reject
SOQLAA	11.5919	0	4.57	Accept	BSCBSCt	10.4345	0	4.47	Accept
SOQCCM	9.685	0	4.37	Accept	BCMBSC	10.1429	0	4.43	Accept
LAASAR	-9.4852	1	2.07	Reject	BCMBSCt	-10.919	1	1.87	Reject
SARCCM	3.3417	0.001152	3.97	Accept	BCMCAC	1.49	0.07351	3.63	Accept
PRMCCM	9.8932	0	4.40	Accept	MCPBCM	10.1429	0	4.43	Accept
RSMCCM	10.4345	0	4.47	Accept	TMCMCP	5.3669	0.000005	4.2	Accept
PRMRSM	11.5919	0	4.57	Accept	TMCBCM	0.3598	0.3608	3.53	Reject
RSMPRM	10.4345	0	4.31	Accept	MCPBSC	11.1542	0	4.53	Accept
NBTRIN	3.4213	0.000937	4.07	Accept	TRUBCP	9.4011	0	4.3	Accept
PRMMIS	6.6669	0	4.15	Accept	BCOTRU	10.7703	0	4.5	Accept
RSMMIS	2.6507	0.006439	3.97	Accept	BCLTRU	9.8932	0	4.4	Accept
					BSCtBSC	5.8446	0.000001	4.3	Accept

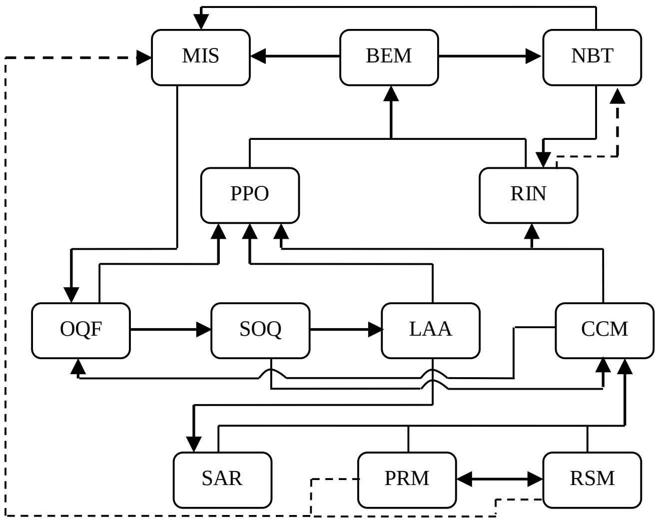


Figure 3.1.2a Diagraph under supplier interest domain

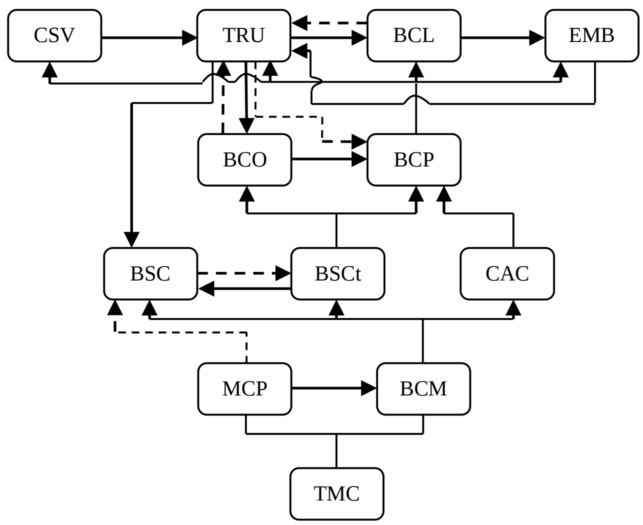


Figure 3.1.2b Diagraph under common interest domain

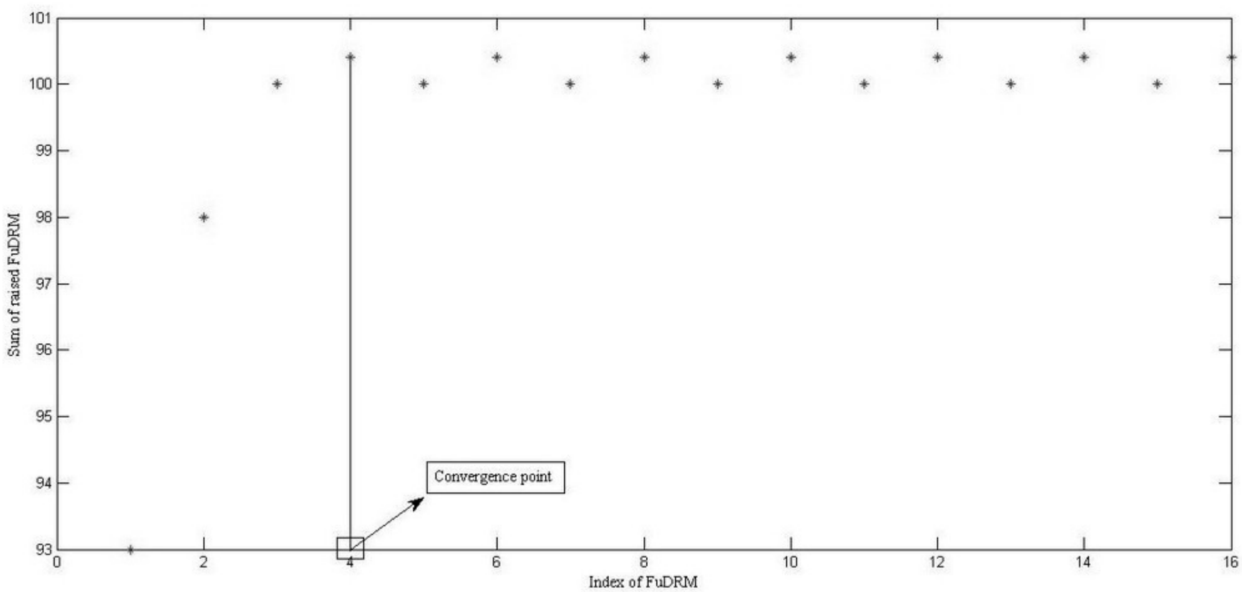


Figure 3.1.3 Convergence of FuDRM under supplier interest domain

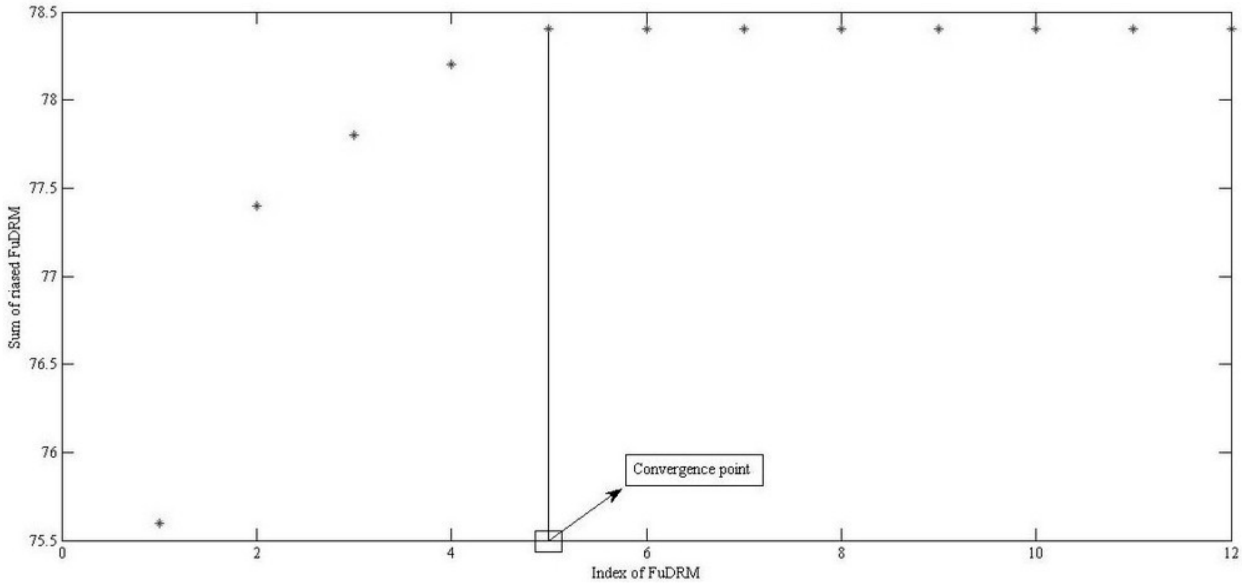


Figure 3.1.4 Convergence of FuDRM under common interest domain

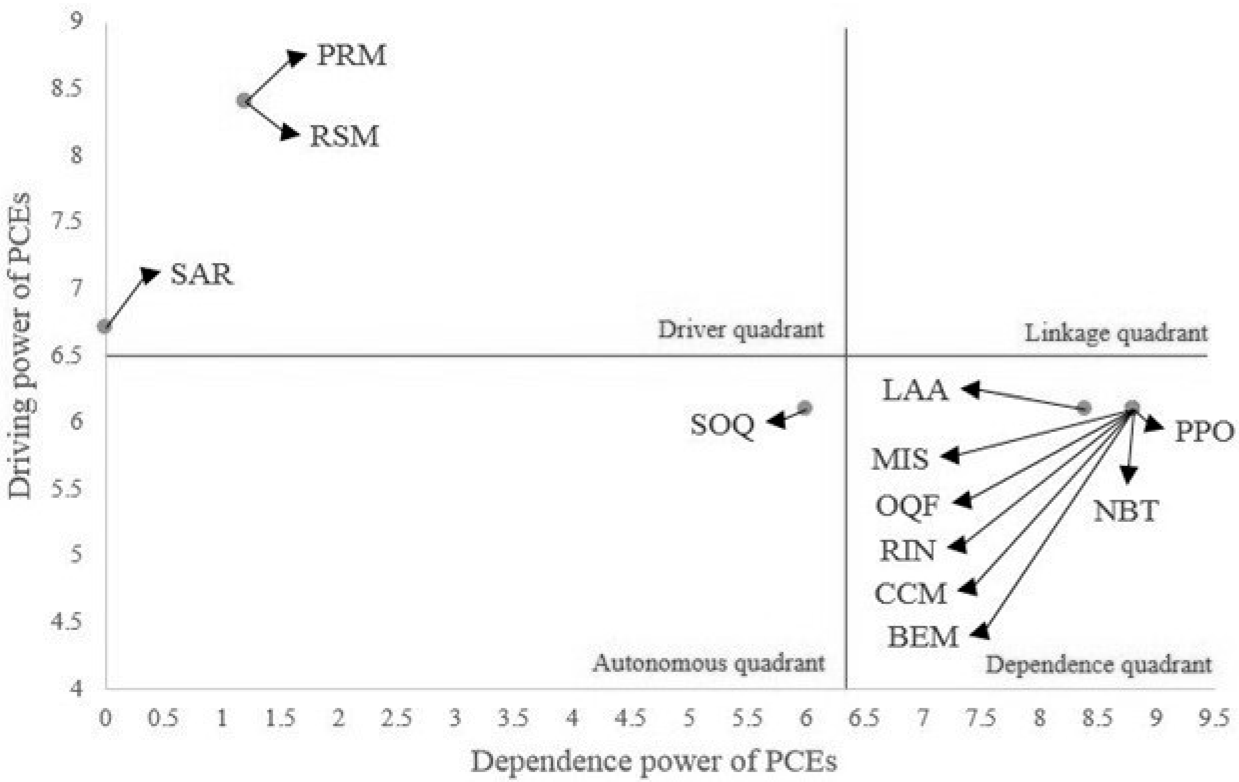


Figure 3.1.5 Driver dependence diagram of PCEs under supplier interest domain

3.1.5.1 Significance of quadrants in the driver dependence diagram

The PCEs plotted on the driver dependence diagrams (Figures 5 and 6) can be classified into four quadrants namely autonomous, dependent, linkage and driver. This division of quadrants is made on the basis of driving and dependence powers of PCEs in making the manufacturer as a preferred customer. The driving power of a PCE can be interpreted as the degree to which it can influence other PCEs in making the manufacturer as a preferred customer. While the dependence power of a PCE signifies, the degree to which it can be influenced by other PCEs. Considering the two levels (i.e. high and low) of driving and dependence power of PCEs, the nature of four quadrants can be characterized. The details and implications of the said four quadrants are discussed below,

Driver quadrant - *(High driving power, Low dependence power)*

A PCE having high driving power but low dependence power is entirely capable of influencing the other PCEs. Thus, the PCEs grouped in this quadrant are controllable in making a manufacturer as a PC of a supplier.

Autonomous quadrant - *(Low driving power, Low dependence power)*

The PCEs with low driving and low dependence powers indicate that they do not have any cause or effect on other PCEs and can be said that they are less related to the system under study. These PCEs do not have any role in making the manufacturer as a PC. Thus, the PCEs grouped in this quadrant can be safely ignored with certain supervisory cautions and actions.

Dependent quadrant - *(Low driving power, High dependence power)*

The high dependence power represents that the improvement to be obtained in these PCEs is solely dependent on the other PCEs. These are important for possibly achieving PCS by a manufacturer and hence, these cannot be ignored. By neglecting these PCEs there is no possibility of maintaining the current preference level ascribed to the manufacturer.

Linkage quadrant - (High driving power, High dependence power)

PCEs falling in this quadrant can be treated as unstable as they have feedback effect on themselves. Any attempt to change these PCEs will make the system of attaining PCS uncontrollable either with unnecessary increased expectations or with total dissatisfaction. However, these PCEs cannot be neglected but they are to be maintained and monitored constantly in order to smoothly achieve the PCS.

3.1.5.2 Classification of PCEs under different domains

The classifications of PCEs (under both supplier interest and common interest domains) along the quadrants and their significance are discussed below.

Classification of PCEs under supplier interest domain

From Figure 5, it can be seen that three PCEs namely PRM, SRM and SAR were grouped in the driver quadrant. Those PCEs falling in this quadrant would actively drive the PCS of a manufacturer, thus it can be interpreted that most of the suppliers look for PRM, SRM and SAR as motives for treating a manufacturer as a PC. Eight out of twelve PCEs were grouped in the dependence quadrant which indicates that majority of the PCEs under supplier interest domain determine the PCS of a manufacturer. Although, these PCEs do not drive the PCS of a manufacturer but still the preferential score ascribed to a manufacturer is indirectly represented by these PCEs. Thus, these PCEs cannot be ignored rather cautiously looked upon for their performance to determine the PCS of a manufacturer. The only PCE i.e. SOQ was fallen in the autonomous quadrant which indicates that the suppliers are not much inspired to offer PCS due to the stability in the ordered quantity. None of the PCEs were fallen in the linkage quadrant, this indicates that PCEs under supplier interest domain are evident to manage.

Classification of PCEs under common interest domain

From Figure 6, it can be seen that all the quadrants have accommodated one or the other PCE. In the driver quadrant, three PCEs namely TMC, BCM, and MCP were clustered, thus these PCEs are to be exercised by both manufacturer and supplier collectively such that they become preferred supply chain partners for each other. By exercising these PCEs, preferential treatments can be extended for each other. Six out of twelve PCEs were clustered in the dependent quadrant and these can only indirectly indicate the preferential status achieved by each other. Two PCEs namely TRU and BSC were clustered in the linkage cluster, these PCEs cannot be directly controlled as they create instability in in the system of achieving preferential status. However, these PCEs improve along with other PCEs and their improvement has to be closely monitored. These PCEs are to be monitored at a certain basic level else the sustenance of the system itself would be at stake. Only one PCE i.e. CAC was fallen in the autonomous quadrant, this indicates that CAC is ineffective to provide any advantage in deriving preferential status for each other.

3.1.6 Sectional summary

In this paper, the PCEs were studied by ISM-FMICMAC analysis method extended with statistical confirmation and have come up with recommendations for a manufacturer in selectively exercising the PCEs. From the obtained results (under supplier interest domain), it was found that manufacturers have to mainly focus on devising the strategies by focusing on the profit and risk sharing mechanisms, resource sharing mechanisms and supplier incentives, rewards and awards of various forms. By doing so, manufacturers would be fulfilling potential interests of their suppliers and will be able to achieve PCS from their suppliers. This is because, in the conducted analysis the aforesaid PCEs have achieved high driving power in improving other set of PCEs (see Figure 2a and Figure 5). Manufacturer's strategic improvements under supplier interest domain can be ascertained by monitoring the effectiveness along the PCEs: [PPO, MIS, RIN, CCM, BEM, NBT, OQF, and LAA] as they are highly dependent. On the other hand (under common interest domain), if a manufacturer and supplier can exhibit top management commitment, conduct mutual visits by competent personnel and have effective communication channels laid out, there is high probability of becoming preferred supply chain partners for each other. From Figure 2b and Figure 6, it can be seen that the said PCEs have high driving power in improving other PCEs. Similarly as discussed before, a manufacturer's strategic improvements under common interest domain can be ascertained by monitoring the effectiveness along the PCEs [BCO, BCP, BSCt, BCL, EMB and CSV] as they are highly dependent. Overall, the current study ranks the PCEs (on the basis of driving and dependence powers) and classify the PCEs in to four quadrants (through driver dependence diagrams). Then a manufacturer is suggested to control certain PCEs having high driving power and consequently monitor the effects through the PCEs having high dependence power under respective domains of interest. This information enables a manufacturer to effectively and efficiently work on the right PCEs that can potentially position it as a PC of a supplier and accordingly have a basis for developing the right PC strategies. Although, the proposed methodology is used in analyzing the PCEs for Indian automotive component manufacturing industry, nonetheless it can also be applied in the other environments. This ends the discussion on the analysis of PCEs, the next section presents about the process of measuring PCS.

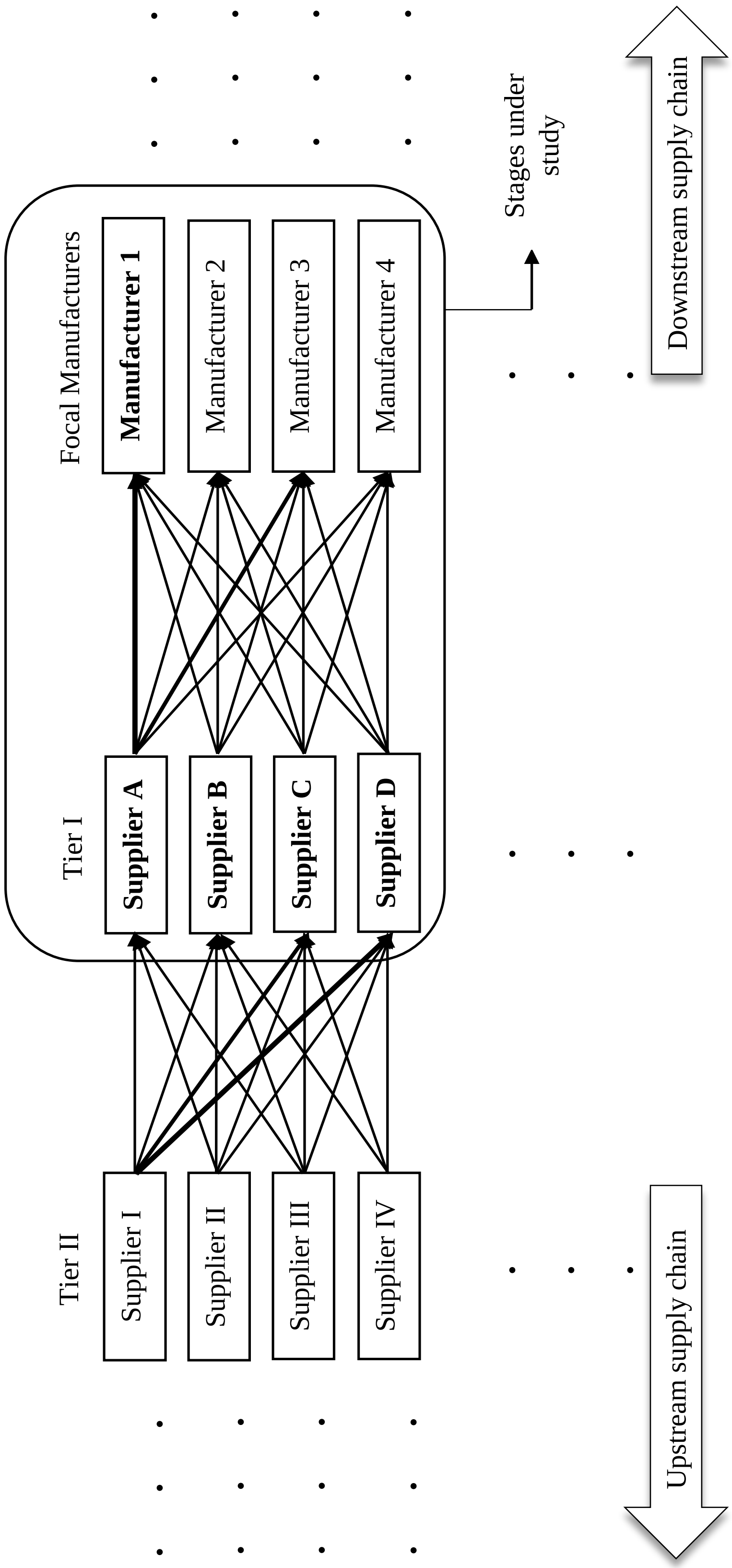
3.2 Sectional abstract to measuring preferred customer status

As most suppliers' role in the value addition process has been elevated to a strategic level, manufacturing supply chains are pushed to establish and develop competitive supply bases. In practice these strategic suppliers often have multiple manufacturing-customers making a particular manufacturer one among several manufacturers competing for the same type of products/services. This makes a supplier implicitly biased in extending and offering its best to few preferred customers, making it difficult for the manufacturer. Hence, it is always a test for a manufacturer to manage and distinguish itself as a preferred customer specifically from its key suppliers' perspective. Although, the concept of preferred customer can bring about a tremendous change in business practice, it has been an ignored topic both in research and practice. Therefore, in this article, a methodology is proposed using extended fuzzy analytic hierarchy process for assisting a manufacturer by providing paradigms to determine its favorable disposition from its key suppliers' perspective. This work forms a basis for a manufacturer to create the best strategies with the right suppliers and in turn secure a definite return on investment.

3.2.1 Introduction to measuring preferred customer status

In this study, it is presumed that manufacturers are the focal manufacturing firms along a manufacturing supply chains and suppliers are the manufacturers' tier-1 outsourced upstream supply chain partners. Further, in this article, the terms "manufacturer," "buyer," "preferred customer," and "customer" are used interchangeably, and all these refer to a focal manufacturing firm. The focused setting of a manufacturer (i.e., Manufacturer 1) and its suppliers (A, B, C, D and so on) along a supply chain is graphically illustrated in Figure 3.2.1.

Figure 3.2.1 Manufacturer and suppliers setting in this work



Note: In this illustration a thicker arrow indicates higher preference ascribed by an upstream member to a downstream member. The supply chain participants considered in the current work are identified using bold above. Dots indicate the other supply chain partners along the supply chains.

Currently, manufacturers have realized the competitive benefits of having good suppliers and are increasing supplier dependency in order to focus on their core competencies. Keeping this in mind, supplier management has acquired an enormous amount of strategic importance in making Supply Chains (SCs) competitive. This is evident from the increased emphasis placed on the role of suppliers in terms of their selection, evaluation, and development. To further strategic relationships with key suppliers, manufacturers have also proposed certain extensive supplier management activities. These activities mainly include, but are not limited to, integrating and managing the performance of suppliers in relation to a manufacturer's internal cross-functional departments; stimulating the flow of technology, knowledge, innovation and other resources, in addition to managing basic flows (i.e. people, material, information and capital); designing the mechanisms of profit and risk sharing and deploying actions to derive confidence, coordination, cooperation, collaboration and compatibility. However, in executing these supplier management activities, manufacturers are often confronted with different sourcing alternatives, namely supplier switching, supplier technology acquisition, or Supplier Development (SD) (Handfield, Krause, Scannell, and Monczka, 2006). Among these sourcing alternatives, SD (broadly defined as a manufacturer's initiative to improve key suppliers' performance in meeting client requirements) is widely chosen by manufacturers as an economical and sustainable alternative to strengthen supply bases (Routroy and Sunil Kumar, 2014).

Although manufacturers are aiming to make supply bases capable through SD Programs (SDPs), such programs have not been effectively utilized. There are many reasons for this shortcoming, as documented in the literature, e.g. Lascelles and Dale (1990), Handfield et al. (2006), and Routroy and Kumar (2015) provide detailed discussion and analysis of SD barriers/impediments. However, ignorance of supplier perceptions of a manufacturer is largely overlooked while executing supplier management activities in implementing the SDPs. From a supplier's perspective, a supplier rationally wishes to provide the best service to its manufacturing-customers or at least services are aimed at meeting its manufacturing-customers' expectations at a minimum level, so as to have business continuity and to support further growth. However, a supplier's extensive support, eagerness to provide the services, and efforts to please a manufacturer depend upon the level of preference it has for its manufacturing-customer. This level of preference, reflecting a supplier's inclination towards a specific favorable manufacturing-customer, is often noted by researchers as "Preferred Customer Status (PCS)."

PCS is given when suppliers evaluate manufacturing-customers and strategically associate with them to derive the best gains for themselves (Nollet, Rebolledo, and Popel, 2012). Nagati and Rebolledo (2013) confirm that trust and PCS are key antecedents of supplier participation in SD activities, and these subsequently have a positive impact on supplier's operational performance. Also, Pulles, Veldman, and Schiele, (2014) state that PCS and SDPs together have a positive effect on a supplier's contribution through innovation.

Essentially, PCS puts a manufacturer in an advantageous position in relation to other manufacturers competing for resources from the same supplier (Schiele, Veldman, Hüttinger, and Pulles, 2012). To demonstrate this point, Kossovsky (2012) conducted a survey, and from the suppliers' responses, he concludes that 75% of suppliers put preferred customers on the top of the list when allocating materials and services; 82% of suppliers allow preferred customers to have first access to new products, ideas, and technologies; and 87% of suppliers offer cost reduction opportunities first to preferred customers. Thus, to reap the benefits of being a preferred customer, a manufacturer has to know the level of preference in order to receive the best resources and services from its strategic and critical suppliers. In this work, we propose a methodology using extended fuzzy analytic hierarchy process that will help a manufacturer to determine its favorable disposition, using PCS at different points in time. This knowledge will enable a manufacturer to have a more robust and competitive supply base in order to more effectively deal with SC dynamics. This process will also make a manufacturer aware of its standing among suppliers. With increasing competition, a manufacturer cannot afford to believe that it will be competitively and unconditionally served by its suppliers. A manufacturer should have a process (as proposed) to analyze its suppliers' perceptions in a timely way, gauge its position in dealings with suppliers, and take the necessary course of action to specifically improve its relationship-based business. This process provides a basis for reemphasizing a supplier's preferential interests and for enabling a manufacturer to market itself as one of the best manufacturers to be associated with. Hence, through this process, a manufacturer can improve with regard to a supplier's preferential interests and capitalize on this by instilling confidence in the supplier that it is earnest in establishing a strong relationship with the supplier. On the other hand, the process also provides a basis for a manufacturer to decide which suppliers to select for SD. In other words, the process ensures that the suppliers selected for development are critical and strategic, the ones who are credible, but are underperforming with respect to a manufacturer's expectations. Lastly, this process can be used as a basis to selectively influence the other suppliers and to promote the manufacturer towards better PCS.

3.2.2 Literature review on preferred customer concept

To make an SC competitive and robust, every stakeholder must mutually promote and carefully look out for each other as the competition is no longer limited to the individual organizations but has been extended to all the members functioning along the SC. The collective SCs are actively built by carrying out joint activities of mutual interest (Hüttinger, Schiele, and Veldman, 2012a).

In this regard, SD has proven to be an effective exercise chosen by a manufacturer to strengthen its supply base. Interestingly, the substantial success in SD can be best achieved when a manufacturer is perceived as a preferred customer by the supplier it is intending to develop (Kumar and Routroy, 2015). Since it is undeniable that suppliers offer preferential treatment to a few manufacturing-customers, a manufacturer can have better success if the manufacturer pursues its SD initiatives as a preferred customer. In spite of the fact that the concept of PCS can bring about a tremendous change in business conduct, this field has been relatively unpursued in both research and practice (Schiele, Calvi, and Gibbert, 2012). The preferred customer concept in the manufacturer-supplier relationships is not a new one and was advocated by Hottenstein as early as 1970. Most early studies (Brokaw and Davisson, 1978; Leenders and Blenkhorn, 1988; Williamson, 1991; and Moody, 1992) conducted on this subject were not properly connected to the published literature related to the preferred customer concept (Schiele et al., 2012). However, within last decade, research in this area has been drawing the attention of researchers.

The most important idea in this “Preferred Customer” concept is the definition of the term itself. Steinle and Schiele (2008) defined a preferred customer as a manufacturing-customer who is awarded preferential allocation of resources by its supplier. It refers to a buying organization receiving better treatment from a supplier as compared to other manufacturing-customers (Nollet et al., 2012). Further, it is said that it is essential for a manufacturer to become a preferred customer to its key suppliers in order to receive complete support in meeting the requirements (Baxter, 2012). For this, a manufacturer should pursue the preferred customer concept as it competes with other manufacturers for services from the same supplier (Kumar and Routroy, 2015). Nollet et al. (2012), explained the same idea from the supplier’s perspective: a supplier continuously evaluates the benefits received from all of its manufacturing-customers, examines the value generated with respect to their expectations, and then interacts with their manufacturing-customers accordingly.

In the practice of the preferred customer concept, branding becomes another important aspect. A supplier becomes attractive to its manufacturing-customer depending upon a manufacturing-customer's ability to market itself better than its competitors. From a manufacturer's perspective, Lindwall, Ellmo, Rehme, and Kowalkowski (2010) identified a similar concept of upstream branding, which a manufacturer must exercise to increase its attractiveness as a manufacturing-customer. The authors submit that manufacturers need to recognize that there is stiff competition for resources and that they are continually evaluated and consequently receive differential treatment from suppliers end. Therefore, a manufacturer has to carefully identify the potential interests of its key suppliers and try to project itself accordingly, while continuing to identify areas for improvement. Table 3.2.1 presents the summary of advantages a preferred manufacturing-customer might receive from a supplier.

Keeping in mind the effect of PCS on SD, the lack of attention to the preferred customer concept, and the advantages in achieving PCS and the aspect of branding, this article proposes a methodology to address the following questions:

- How can a manager gauge the preferential status of a manufacturer from a key supplier's point of view?
- How can a manager monitor a manufacturer's preferential status at different points in time?
- How can a manager conduct preferential performance management for effective supplier development?

Attributes that enable a manufacturer to become a preferred customer were identified through a literature review, brainstorming sessions, and discussions held with industry and academic experts. These attributes were categorized into three Preferred Customer Components (PCCs) in consultation with experts and are referred as Supplier’s Expectations Component (SEC), Manufacturer’s Characteristics Component (MCC) and Common Interests Component (CIC). Tables 3.2.2, 3.2.3 and 3.2.4 present categorized lists of attributes under SEC, MCC, and CIC, respectively, along with brief descriptions and corresponding references supporting their role in making a manufacturer a supplier’s preferred customer. These attributes form a general list to consider in formulating a PCS. These attributes were selected from the literature, as they were identified in relationship to the preferred customer concept. The references identified were noted, as these references used the identified attribute in the analysis of PCS of a manufacturer. However, owing to different environments in which a manufacturer and supplier operate, the list must be subjected to a series of screening tests, e.g. redundancy test, accountancy test, relevancy test, significance test and directional test, before a manufacturer can select the appropriate attributes to determine its PCS. After determining its PCS from key suppliers, a manufacturer can then assess its chance to access the best of the resources and services from a supplier and accordingly deploy its SD initiatives. Ultimately, the responsibility remains on a manufacturer to know its position, to develop appropriate strategies with suppliers, and in turn secure an acceptable return on investment.

Table 3.2.1 Advantages of Preferred Customer Status for a Manufacturing-customer

Support from the literature	Advantages of becoming a preferred customer
Booth, (1996); Schiele, Veldman, and Hüttinger, (2011); and Nollet et al., (2012)	Improved flexibility and benevolent pricing
Olsen and Ellram, (1997); Ellegaard and Ritter, (2007); and Nollet et al., (2012)	Better product quality and availability, support in the sourcing process, delivery or/and pricing
Christiansen and Maltz, (2002)	Enable to reduce inventory levels; technology sharing and problem resolution
Ellegaard, Johansen, and Drejer, (2003); and Baxter, (2012)	Increased supplier commitment
Ritchie and Brindley, (2007)	Extend long term sustainable relationship
Cordón and Vollmann, (2008)	Share development projects; resources; attain higher service levels; achieve deployment of best of the resources from supplier in providing the services
Hald, Cordón, and Vollmann, (2009)	Obtain needful information and assistance in product or process development; get quick response from the suppliers to the problems; reduce lead times; reduce supply chain costs
Schiele, Veldman, and Hüttinger, (2011)	Enhanced supplier performance
Schiele, Veldman, and Hüttinger, (2011); Schiele, (2012); and Ellis, Henke, and Kull, (2012)	Early access to technological innovation from the suppliers
Mortensen, (2012); and Baxter, (2012)	Receive preferential investments
Baxter, (2012)	Supplier cooperation
La Rocca, Caruana, and Snehota, (2012)	Improved attractiveness

Table 3.2.2 Attributes of Supplier's Expectations Component

Attribute	Support from the literature
Prompt Payments of Outstanding bills (PPO)	Chopra and Meindl (2007); Jones (2008)
Manufacturer's pull on Inventory from Supplier (MIS)	Martínez-de-Albéniz and Simchi-Levi (2013)
Ordered Quantity and Frequency (OQF)	Xia *et al.* (2008); Wee and Widyadana (2013); Hu *et al.* (2013)
Stability in Ordered Quantity (SOQ)	Ramsay and Wagner (2009); Wee and Widyadana (2013)
Level of Aggregation achieved (LAA)	Choi *et al.* (2001);Trent and Monczka (2003)
Returns on Innovation (RIN)	Ramsay and Wagner (2009); Narasimhan and Narayanan (2013); Yeniyurt *et al.* (2014); Wagner and Bode (2014)
Supplier Awards and Recognition (SAR)	Dedhia (1990); Klassen and Vachon (2003); Sucky and Durst (2013)
Profit and Risk sharing Mechanism (PRM)	Hüttinger *et al.* (2012)
Resource Sharing Mechanism (RSM)	Kanda and Deshmukh (2008); Yan and Dooley (2014)
Contract's design with Conflict Management (CCM)	Cox (2004); Dahwa *et al.* (2013); Yan and Dooley (2014)
Business Expectancy from the Manufacturer (BEM)	Hald *et al.* (2009); Mortensen and Arlbjørn (2012); Schiele *et al.*(2012)
Nimble Business Transactions (NBT)	Cox (2004); Steven *et al.* (2014)

Table 3.2.3 Attributes of Manufacturer's Characteristics Component

Attribute	**Support from the literature**
Order Winning Capability (OWC)	Fynes and Voss (2002); Vieira *et al.* (2013); Fawcett and Waller (2013)
Growth in the Market Share (GMS)	Song *et al.* (2012); Govindarajan and Trimble (2012); Hüttinger *et al.* (2012); Sullivan *et al.* (2012)
Targets achieved towards Mission and Vision (TMV)	Caddick and Dale (1998); Sommer (2004)
Knowledge and Business Skills Development (KBD)	Parikh, (2001); Ramsay and Wagner (2009); Graebner *et al.* (2010)
Corporate Social Responsibility (CSR)	Duffy *et al.* (2013); Pulles *et al.* (2014)
Competitive Position in the Market (CPM)	Mortensen (2012); Hüttinger *et al.* (2012); Baxter (2012); Nagati and Rebolledo (2013)
Global Presence (GLP)	Johansson and Ronkainen (2005); Raizada (2011); Lockström and Lei (2012); Horn *et al.* (2014)
Business Process Reengineering (BPR)	Sommer (2004); Hüttinger *et al.* (2012)
Strength of Leadership (SOL)	Quayle (2000); Meehan and Wright (2011)
Financial Capability (FIC)	Ramsay and Wagner (2009); Park *et al.* (2010); Hüttinger *et al.* (2012); Baxter (2012)
Brand Value (BRV)	Ramsay and Wagner (2009); Raizada (2011); Nollet *et al.* (2012)
Technological Capability (TEC)	Park *et al.* (2010); Hüttinger *et al.* (2012)

Table 3.2.4 Attributes of Common Interests Component

Attribute	**Support from the literature**
Mutual visits by Competent Personnel (MCP)	Hüttinger *et al.* (2012); Nollet *et al.* (2012); Ellegaard and Koch (2012)
Cost Savings and Value addition achieved (CSV)	Christiansen and Maltz (2002); Winter and Lasch (2011); Schiele *et al.* (2011); Nepal, Yadav, and Solanki (2011)
Trust (TRU)	Hald *et al.* (2009); Dahwa *et al.* (2013), Yeniyurt *et al.* (2014); Horn *et al.* (2014)
Top Management Commitment (TMC)	Schiele (2010); Nollet *et al.* (2012); Schiele *et al.* (2011); Horn *et al.* (2014)
Buyer-Supplier Cooperation (BSC)	Forker and Stannack (2000); Caniëls *et al.* (2013); Leuschner *et al.* (2013)
Buyer-Supplier Coordination (BCO)	Winter and Lasch (2011); Mortensen (2012); Yan and Dooley (2014)
Buyer-Supplier Collaboration (BCL)	Park *et al.* (2010); Najafi Tavani *et al.* 2013
Buyer-Supplier Communication (BCM)	Leon and Farris (2011); Nollet *et al.* (2012); Hüttinger *et al.* (2012); La Rocca *et al.* (2012); Yeniyurt *et al.* (2014)
Buyer-Supplier Compliance (BCP)	Ellegaard *et al.* (2003); Hoffmann *et al.* (2013)
Buyer-Supplier Compatibility (BSCt)	Hüttinger *et al.* (2012); Lager and Storm (2012); Arroyo-López *et al.* (2012)
Certifications and Accreditation (CAC)	Cox (2004); Mwikali and Kavale (2012); Arroyo-López *et al.* (2012);
Ethical and Moral Business Values (EMB)	Ramsay and Wagner (2009); Schiele *et al.* (2011); Ellis *et al.* (2012b)

3.2.3 Methodology

A manufacturer must have a process to determine its stature of PCS from key suppliers' perspective. For this, we propose here a methodology using an extension to Fuzzy Analytic Hierarchy Process (FAHP). Here, FAHP was specifically chosen as it is one of the simplest and most effective methods to determine the significance of attributes in making a manufacturer a preferred customer. Following the analysis, a fuzzfied performance rating of a manufacturer along the attributes with various suppliers are captured at different points in time. The resultant fuzzy performance measures are determined and the gaps from predefined performance levels are measured to obtain a manufacturer's level of PCS.

The methodology is described using a flowchart and is presented in Figure 3.2.2. Data collection is summarized next, followed by a summary of the steps used to determine the PCS of a manufacturer.

Data Collection:

To begin, it is important to note that although feedback from suppliers is essential, responses regarding preferential treatment offered to a manufacturer may not be completely accurate. This is due to the fact that a manufacturer is a customer and a supplier's responses are likely to be expressed in favorable terms. In addition, when a supplier is not performing well, the supplier may resort to demanding input from the manufacturer and use the lack of input as an excuse for the supplier's own poor performance. To negate such biased feedback, data collection may need to be limited to manufacturing personnel who are in close contact with suppliers to enable a realistic assessment of responses provided. However, the process of data collection should not be biased either in favor of a supplier or a manufacturer.

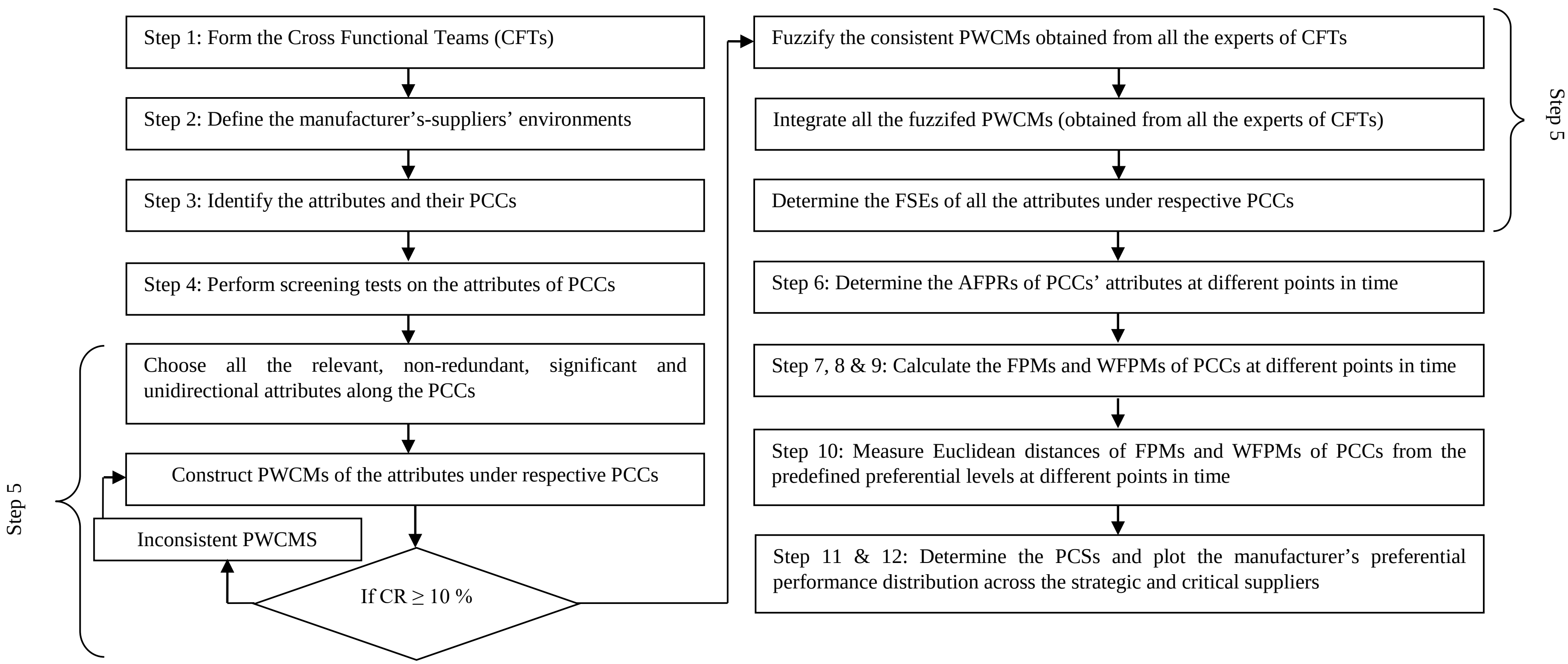


Figure 3.2.2 Measuring preferred customer status of a manufacturer

Step 1: Formation of Cross Functional Teams (CFTs)

In this first step, a CFT is formed consisting of experts drawn from people in multiple departments of a manufacturer, who are closely connected with suppliers, and possessing adequate knowledge, skills, and experience in supply management and manufacturer-supplier environments.

Step 2: Definition of Manufacturer's-Suppliers' Environments

In Step 2, the manufacturer-supplier environments under study are defined to identify feasibilities and infeasibilities, strengths, opportunities, weaknesses, threats, characteristics, perspectives and expectations of participating supply chain partners. This exercise must be carried out by involving personnel from top management to lower-level workers from the manufacturer's side, who are closely connected to business processes with key suppliers. This will enable a realistic assessment of the context and allow participants to focus on the systems under study, and to share their opinions and experiences.

Step 3: Identification of relevant PCCs

Next, the group of components that reflect the PCS of the manufacturer from the supplier's point of view and the corresponding attributes under each component replicating the specific manufacturer-supplier environments are identified (see step 2). These attributes have to be further processed by subjecting them to a series of screening tests in order to determine which attributes are relevant, given the environment.

Step 4: Performance of screening tests on PCCs' Attributes

Attributes are subjected to screening tests in terms of relevancy, accountancy, redundancy, gross level significance, and directional tests to identify attributes that reflect the current context. The relevancy test is conducted to determine whether all attributes are applicable and in line with the characteristics of current manufacturer-supplier environments. An accountancy test is performed to determine whether or not all the requisite and sufficient attributes are considered. The redundancy test is carried out to eliminate repeated attributes. The gross level significance test is conducted to eliminate unimportant attributes, which in turn, helps the manufacturer to direct energy and resources on the most important and significant attributes. The directional test is conducted to obtain uniformity across attributes with respect to their influence (direct/indirect) on the corresponding PCC. All attributes are converted into either direct or indirect.

Step 5: Determination of Fuzzy Synthetic Extent for each PCC's attribute

In this step, the Fuzzy Synthetic Extent (FSE) for each attribute's weight using the FAHP method is determined. Triangular Fuzzy Numbers (TFNs) are used to express the FSE of an attribute '*i*' and is denoted by W_i. The following steps detail the procedure for calculating FSEs.

Step 5.1: Construction of Pairwise Comparison Matrices (PWCMs) of attributes

The relative importance between attributes using PWCMs from each CFT are captured. These pairwise comparisons should be carried out using a 1-10 scale (Saaty, 1990). See Table 3.2.5.

Step 5.2: Check the consistency of PWCMs

A consistency check is conducted to ensure that the pairwise comparisons of attributes are performed without any inconsistency in opinions. Consistency is measured using a consistency ratio, calculated as follows: each column's values of PWCMs is normalized by dividing each entry by the sum of the column-wise entries. The average of the entries across each row is calculated next. This forms the Principal Vector (PV). If a PWCM is denoted as M_1, and the principal vector is denoted as M_2, then $M_3 = M_1 * M_2$ and $M_4 = M_3/M_2$. If λ_{max} is the average of the attributes of M_4, then the Consistency Index *(CI)* can be calculated as $CI = \frac{\lambda_{max} - N}{N - 1}$, where '*N*' is the number of attributes under the corresponding PCC. The Consistency Ratio *(CR)* is calculated by $CR = \frac{CI}{RI}$, where *RI* is the random index corresponding to '*N*'. Refer to Thomas (2000) for *RI* values. If the *CR* value is less than or equal to 10%, then the judgments can be considered consistent. If not, the CFTs have to improve their judgments in such a way that CR≤ 10%.

Table 3.2.5 Scale for pairwise comparisons (Source: Saaty, 1990)

Importance measure	**Definition**
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, 8	Intermediate values between the two judgements
Reciprocals	If an attribute *i* is given any one of the above importance measure when compared with an attribute *j* then the importance measure will be reciprocal when *j* compared to *i*
Ratios	Ratios arising from the scale

Table 3.2.6 Membership functions of the fuzzy numbers (Source: Lee, 2009)

Crisp judgment of pairwise matrix	**Triangular Fuzzy Number (TFN)**
1	(1,1,2)
2	(x-1, x, x+1) for x = 2,3,…,8
9	(8,9,9)
1/1	(2-1,1-1,1-1)
1/x	((x+1)-1,x-1,(x-1)-1) for x = 2,3,…,8
1/9	(9-1,9-1,8-1)

Step 5.3: Fuzzification of PWCMs of each Expert (Lee, 2009)

The individual PWCMs obtained from each CFT are "fuzzified" by replacing the elemental values with corresponding TFNs, as shown in Table 3.2.6. The TFNs corresponding to the comparison of an attribute 'i' with 'j' for the CFT 'k' is denoted as $(P_{ijk}, Q_{ijk}, R_{ijk})$.

Step 5.4: Integration of fuzzified PWCMs

The individual, fuzzified PWCMs are integrated using the geometric mean method (Lee, Kang, and Chang, 2009). The resultant integrated matrix consists of the elements in TFNs as denoted by(a_{ij}, b_{ij}, c_{ij}). See the equations mentioned below.

$$a_{ij} = \left\{ \prod_{t=1}^{s} P_{ijk} \right\}^{1/s} \quad \forall i, j = 1, 2, \ldots, N$$

$$b_{ij} = \left\{ \prod_{t=1}^{s} Q_{ijk} \right\}^{1/s} \quad \forall\, i, j = 1, 2, \ldots, N$$

$$c_{ij} = \left\{ \prod_{t=1}^{s} R_{ijk} \right\}^{1/s} \quad \forall i, j = 1, 2, \ldots, N$$

Where 's' denotes the number of CFTs providing judgments.

Step 5.5: Determination of FSEs of attributes under each PCC

The FSE for each attribute 'i' denoted by W_i as shown next (Chang, 1996; Lee, 2009; Lee et al., 2009; and Lee, Kang, Hsu, and Hung, 2009) is calculated. See the equation mentioned below.

$$W_i = \left(m_i^-, m_i, m_i^+ \right) = \left\{ \frac{\sum_{j=1}^{N} a_{ij}}{\sum_{i=1}^{N} \sum_{j=1}^{N} c_{ij}}, \frac{\sum_{j=1}^{N} b_{ij}}{\sum_{i=1}^{N} \sum_{j=1}^{N} b_{ij}}, \frac{\sum_{j=1}^{N} c_{ij}}{\sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij}} \right\} \forall i = 1,2,\ldots,N$$

Step 6: Determination of average fuzzy performance rating for each attribute

The Average Fuzzy Performance Ratings (AFPRs) for each attribute is determined based on CFT's judgments at multiple points in time, e.g. every quarter, six months, or year. The AFPR expressed in terms of TFN for attribute 'i' is denoted by 'R_i'. The procedure for finding the AFPRs of attributes is summarized next.

Step 6.1: Collection of experts' judgments on performance rating of each attribute

Performance Ratings (PRs) of attributes in terms of linguistic expressions are calculated in this sub-step along past, present and target points in time from CFTs. These linguistic expressions are replaced by corresponding TFNs as shown in the Table 3.2.7.

Table 3.2.7 Linguistic judgements for performance ratings (Source: Vinodh, Devadasan, Vimal, and Kumar, 2013)

Linguistic expressions	**Notation for expression**	**Corresponding Triangular Fuzzy Number (TFN)**
Worst	W	(0,0.5,1.5)
Very poor	V	(1,2,3)
Poor	P	(2,3.5,5)
Fair	F	(3,5,7)
Good	G	(5,6.5,8)
Very Good	VG	(7,8,9)
Excellent	E	(8.5,9.5,10)

Step 6.2: Determination of average fuzzy performance rating

The AFPR of each attribute (with respect to past, present and future points in time) is determined by aggregating the multiple inputs using the arithmetic mean. The AFPR of an attribute 'i' is denoted by R_i and calculated as shown in the equation below.

$$\overline{R_{it}} = \frac{\sum_{k=1}^{s} R_{itk}}{s} \forall t = 1,2,\ldots,n; \forall i = 1,2,\ldots,N$$

Step 7: Calculation of Fuzzy Performance Measure (FPM)

The FPM along each point in time (past, present and target) is calculated by using the following equation.

$$FPM_{PCC} = \frac{\sum_{i=1}^{N} (W_i * \overline{R_{it}})}{\sum_{i=1}^{N} (W_i)} \forall t = 1,2,\ldots,n; \forall PCC = \{SEC, MCC, CIC\}$$

Step 8: Determination of Weighted Fuzzy Performance Measure (WFPM)

In this step, the WFPMs are determined using the FPMs calculated in the previous step, under the three PCCs (SEC, MCC and CIC) at multiple points in time. For ease in formulation and analysis, these components are assumed to be linear and independent as shown in the following equation.

$$WFPM_t = \alpha \times FPM_t^{SEC} + \beta \times FPM_t^{MCC} + (1 - \alpha - \beta) \times FPM_t^{CIC}$$

Where, $WFPM$: Weighted Fuzzy Performance Measure, $t = 1,2,3 \ldots n$; $\alpha, \beta and\ 1 - \alpha - \beta$ are the individual weights assigned to the PCCs). The procedure for calculating these weights is described next.

Step 9: Calculating weights of PCCs

The FSEs of PCCs are calculated as outlined in Steps 5.1 through 5.5 as per the procedure detailed from steps 5.1 to 5.5. These FSEs' are further compared against each other to ascribe a value called the Degree of Possibilities (DOPs) for each component. From the DOPs for each component, a minimum value is selected, and these minimum value DOPs for each component are further normalized to obtain PCC weights, which are denoted as α for SEC, β for MCC and $(1-\alpha-\beta)$ for CIC. The following equation is used to determine DOPs $\mu(F_i)$ (Chang, 1996; Lee, 2009; Lee et al., 2009; and Lee, Kang, Hsu, and Hung, 2009),

$$\mu(F_2 \geq F_1) = \begin{cases} 1, & m_2 \geq m_1 \\ 0, & m_1^- \geq m_2^+ \\ \dfrac{[m_1^- - m_2^+]}{[(m_2 - m_2^+) - (m_1 - m_1^-)]} & otherwise \end{cases}$$

Using the weights obtained, the corresponding weighted fuzzy spreads of the components at respective points in time are integrated to obtain WFPMs.

Step 10: Measuring Euclidean distances from predetermined preferential levels

The preferential levels are predefined in consultation with the CFT members along with their expressions in terms of TFNs. See Table 3.2.8. These expressed TFNs are largely environment-specific and cannot be generalized. Next, the Euclidean distance of WFPMs with reference to these predefined preferential levels are computed by using the following equation (Vinodh, Devadasan, Vimal, and Kumar, 2013):

$$D\ (WFPM_t,\ PL_k) = \left\{ \sum_{x \varepsilon p} (f_{WFPM}(x) - f_{PL_k}(x))^2 \right\}^{1/2}$$
$$\forall t = 1, 2, \ldots, n; \forall k = \{EP, VP, MP, FP, SP\}$$

Where $f_{WFPM}(x)$ represents the Weighted Fuzzy Performance Measure and $f_{PL_k}(x)$ represents the predefined preferential level $'k'$.

Table 3.2.8 Predefined preferential levels with corresponding TFNs and percentages (Source: Vinoth *et al*., 2013)

Predefined Preferential Level (PL_k)	Notation for PL_k	Corresponding TFN ($f_{PL_k}(x)$)	Percentage
Extremely Preferred	EP	(7,8.5,10)	100 %
Very much Preferred	VP	(5.5,7,8.5)	80 %
Moderately Preferred	MP	(3.5,5,6.5)	60 %
Fairly Preferred	FP	(1.5,3,4.5)	40 %
Slightly Preferred	SP	(0,1.5,3)	20 %

Step 11: Determination of PCS

The minimum among the Euclidean distances represents the corresponding PCS of the manufacturer with respect to the PCC and the point in time. It is further converted to a percentage. Table 3.2.8 shows the predefined preferential levels along with corresponding TFNs and percentages. These percentage scores convey the preferential status ascribed by the supplier to the manufacturer under each component and at different points in time.

Step 12: Plot the manufacturer's preferential performance distribution along the suppliers

The manufacturer's PCS ascribed by all the strategic and critical suppliers are determined next. Thereafter, the WFPMs of all suppliers (obtained in Step 8) are used to calculate the crisp scores (manufacturer's preferential scores) by using the equation of defuzzification as shown below (Kwong and Bai, 2003).

$$CS_{ij} = \frac{(l_{ij} + 4m_{ij} + n_{ij})}{6}$$

Where, CS_{ij}: crisp score ; l_{ij}: left spread of the performance measure; m_{ij}: mean value of the performance measure; and n_{ij}: right spread of the performance measure.

Next, suppliers are rated according to their strategic and critical nature on a 1-10 scale, where lower numbers indicate the most strategic and critical. The manufacturer's preferential performance distribution is plotted using the manufacturer's preferential scores (along the y-axis) and the ratings of the suppliers (along the x-axis).

This methodology was coded using MATLAB 2013b to remove the computational burden on users. The next section discusses with the application of the proposed methodology in an Indian manufacturing company in order to validate the method and to illustrate the salient features of the methodology.

3.2.4 Application of the proposed methodology in an Indian manufacturing company

An Indian automotive component and vehicle manufacturing company was approached to test the proposed methodology. To keep the identity of the company anonymous, it is named Company 'I'. The Company 'I' is a large-scale manufacturing company with a gross turnover of more than ₹50 billion. Its primary business is to manufacture highly customized, as well as standardized products. It has been known for innovative manufacturing processes, high quality yet competitively priced parts, strong leadership and corporate social responsibility initiatives. The company started in the automotive domain and gradually extended into locomotive, earth movers and aerospace industries. It has recorded consistent growth and is strategically expanding its presence nationally and internationally. To meet global standards, as well as to breed more innovation into its core competencies, Company ‘I’ has outsourced many non-core processes to other manufacturers (i.e., suppliers). Further, the company has adopted SDPs to make its critical and strategic suppliers capable and innovative. In spite of these initiatives, there were numerous challenges Company ‘I’ faced in extracting the best value-addition from its suppliers and in implementing its SD initiatives. Thus, senior executives were interested in the proposed methodology’s intent and encouraged its application within the company.

Experts from various departments were invited, and three CFTs were formed (named as P, Q and R). Each CFT was comprised of eight members, who were all senior executives of the company with more than 10 years of experience. Next, the methodology was explained to them to obtain their feedback. As per Step 2 of the methodology, the characteristics of the manufacturer and its suppliers’ environments were defined. Since the company offers a wide variety of customized products, it has to leverage internal and external (i.e. outsourced to suppliers) manufacturing systems with changing demand and requirements. The company has categorized the supply base by clients and their requirements. To competitively increase variety, the company has placed more emphasis on supplier innovation and its flow into the organization. Further, with respect to supplier management, the company has been very strategic in developing the diversity of its supply base.

On the supply side, the CFTs chose a group of nine suppliers (referred to here as A, B, C, D, E, F, G, H and I) which have common performance gaps in meeting the Company I’s requirements. The chosen suppliers were medium-scale automotive ancillary part manufacturing companies, supplying a significant portion of company I’s outsourced orders. Similar to the manufacturer, these suppliers also manufacture customized parts following various manufacturers’ requirements. These suppliers have been in the manufacturing business for many years and have developed a broad manufacturing-customer base. Almost all of these suppliers are oligopolistic in nature, however, they have seen increasing competition from local, as well as foreign manufacturers. Thus, the suppliers are also pushing to specialize and achieve secured manufacturing levels by partnering with reputed manufacturers across the industry. It was with these types of suppliers, that the Company 'I' was eager to know its preferential status.

Having defined the manufacturer and supplier operating environments, the identified group of PCCs along with the lists of attributes (Step 3) were shared with the CFTs. Screening tests (Step 4) were conducted to shortlist and obtain the right set of attributes under each component. The CFT members were skeptical and conservative about excluding any attribute and so all the identified attributes were selected for analysis. According to Step 5, the FSEs of attributes under three PCCs (i.e. SEC, MCC, and CIC) were determined. Determination of FSEs of attributes under the SEC alone are discussed in this section. As per Step 5.1, PWCMs of SEC attributes were constructed, and CFTs were asked to express their opinions using the scale shown in Table 3.2.5. Following Step 5.2, PWCMs were checked for consistency. The consistent PWCMs were further fuzzified by following the membership functions shown in Table 3.2.6. The fuzzified PWCMs from all CFTs were then integrated as per Step 5.2. Thereafter, following the Step 5.5, the FSE of each attribute (W_i) was calculated.

At this juncture, PRs of each attribute at different points in time (past-year, present-year, and future-year) were collected in the form of linguistic expressions and fuzzified (see Table 3.2.7) as mentioned in the Step 6.1 and APRs were calculated according to Step 6.2. On the basis of the APR and FSE of each attribute, the FPM of each component was determined according to Step 7. After determining FPMs of PCCs, the weights of PCCs were determined by calculating their DOPs (Step 8). Weights obtained for SEC, MCC and CIC were $\alpha = 0.288$, $\beta = 0.157$ and $(1- \alpha - \beta) =$

0.554, respectively. These weights were correspondingly used to determine the WFPM at different points in time. Using these FPMs and WFPMs, the Euclidean distances were measured from the predefined preferential levels shown in Table 3.2.8. Table 3.2.9 shows these Euclidean distances obtained for each PCC at different points in time. According to Step 12, the PCSs of the manufacturer, across all nine suppliers at each point in time were determined. During the process, the crisp scores (manufacturer's preferential scores) from WFPMs of all the suppliers (at present point in time) were extracted. Further, CFTs were asked to rate the suppliers based on the strategic and critical nature of the supplies from each supplier. On the basis of these preferential scores and supplier ratings, a manufacturer's preferential performance distribution across the nine suppliers was created. See Figure 3.2.3. The next section discusses and interprets the results.

3.2.5 Results and discussion

The results are discussed in the following sub-sections: significance of Preferred Customer Components (PCCs) in ascribing Preferred Customer Status (PCS), PCSs achieved under SEC at different points in time, overall PCS achieved at different points in time, and preferential performance distribution along suppliers.

3.2.5.1 Significance of PCCs in ascribing PCS

The obtained weights for SEC, MCC and CIC were 0.288, 0.157 and 0.554, respectively. Based on the weights obtained, the order of importance for suppliers to rank preferred manufacturers can be inferred as CIC > SEC > MCC. This order indicates that the suppliers are more concerned with the CIC in ascribing the preferential status to manufacturing-customers.

3.2.5.2 PCSs achieved under SEC at different points in time

From the obtained weights of PCCs, the FPMs of the suppliers were calculated under each PCC along with WFPM. Further, FPMs were related to a predefined scale and their Euclidean distances from different levels were measured at each point in time of past, present, and future (target). Although results for nine suppliers were determined, only the results related to supplier 'C' are discussed in this section. The obtained Euclidean distances of FPMs (under SEC, MCC and CIC) and WFPM from the predefined preferential levels at different points in time are shown in Table 3.2.9. Based on the obtained lowest Euclidean distances (highlighted as bold with grey background) the PCSs and the corresponding percentage preferences ascribed to the manufacturer at different points in time are presented in Table 3.2.9. Under Euclidean distances from FPM_{SEC}, the manufacturer acquired a "Moderately Preferred (MP)" level in the past (value of 1.99), "Very much Preferred (VP)" level in the present (value of 1.67), and "Extremely Preferred (EP)" level (value of 1.09) for the future. These values can be interpreted to mean that the manufacturer could improve its present preferential status compared to its past standing, while the target for the future is upgraded to the next level of preferred status. Similarly, based on the Euclidean distances from FPM_{MCC}, the manufacturer achieved "VP" level in the past, "VP" level in the present, and "EP" level for the future, with values of 0.57, 0.37 and 0.81, respectively. These values indicate that the manufacturer under MCC reached "very much preferred" level in the past and continues at the same level, while it was expected to achieve the target of "extremely preferred" level in the future. Based on the Euclidean distances from FPM_{CIC}, the manufacturer followed the same trend as SEC with 1.48, 1.15 and 1.21 values for past, present, and future, respectively. These values indicate that the manufacturer moved from "moderately preferred" level in the past to "very much preferred" level in the present, while the target was set to be "extremely preferred" in the future.

Based on the magnitudes of the obtained Euclidean distances, it can be inferred that under SEC and CIC, the manufacturer has room for improvement in its PCS. However, under MCC, it can be said that the manufacturer is characteristically attractive to the supplier 'C' and requires less work to achieve the target.

3.2.5.3 Overall PCS achieved at different points in time

WFPM's Euclidean distances summarized in Table 3.2.9 provide a measure of the overall PCS of the manufacturer. The manufacturer achieved "MP" level in the past, "VP" level in the present, and is expected to be at "EP" level with 1.60, 1.14 and 1.07 values respectively. These indicate that the manufacturer's status improved from "moderately preferred" to "very much preferred" and has a target to be "extremely preferred." In other words, on a scale of percentage preference (equivalent to the preferential levels) it can be read as, the manufacturer achieved an 80% preference level in the present timeframe while the target is set at 100% preference level.

3.2.5.4 Preferential performance distribution along the suppliers

Similar to the formerly discussed results for Supplier C, the PCS of all the nine suppliers was calculated. Subsequently, the manufacturer's preferential scores and ratings (based on strategy and criticality of the sup0plies provided by each supplier) of the nine suppliers were obtained and were plotted as shown in Figure 3.2.3. Based on the distribution of data, the nine suppliers were divided into two clusters. The suppliers in Cluster 1 perceived the manufacturer as relatively preferred and their supplies were more strategic and critical for Company 'I' in comparison to those in Cluster 2. Interestingly, the top strategic and critical suppliers perceived Company 'I' as more preferred. As a result of these findings, the manufacturer should direct much of its SD efforts towards the suppliers in Cluster 1. For suppliers in Cluster 2, the manufacturer must take steps to gain-

Table 3.2.9 Euclidean distance measures of Fuzzy Performance Measures of PCCs at different points in time

PL	Euclidean distances from FPM_{SEC}			Euclidean distances from FPM_{MCC}			Euclidean distances from FPM_{CIC}			Euclidean distances from WFPM			Percentage Preference
	Past	Present	Target	Past	Present	Target	Past	Present	Target	Past	Present	Target	
EP	5.14	4.26	**1.09**	3.16	2.94	**0.81**	4.63	3.74	**1.21**	4.49	3.74	**1.07**	100 %
VP	2.56	**1.67**	3.30	**0.57**	**0.37**	2.72	2.05	**1.15**	3.49	1.90	**1.14**	3.28	80 %
MP	**0.99**	1.81	6.70	2.90	3.13	6.11	**1.48**	2.32	6.88	**1.60**	2.33	6.67	60 %
FP	4.41	5.27	10.14	6.36	6.59	9.56	4.92	5.78	10.33	5.05	5.79	10.12	40 %
SP	7.00	7.87	12.73	8.96	9.19	12.15	7.51	8.38	12.92	7.65	8.39	12.71	20 %

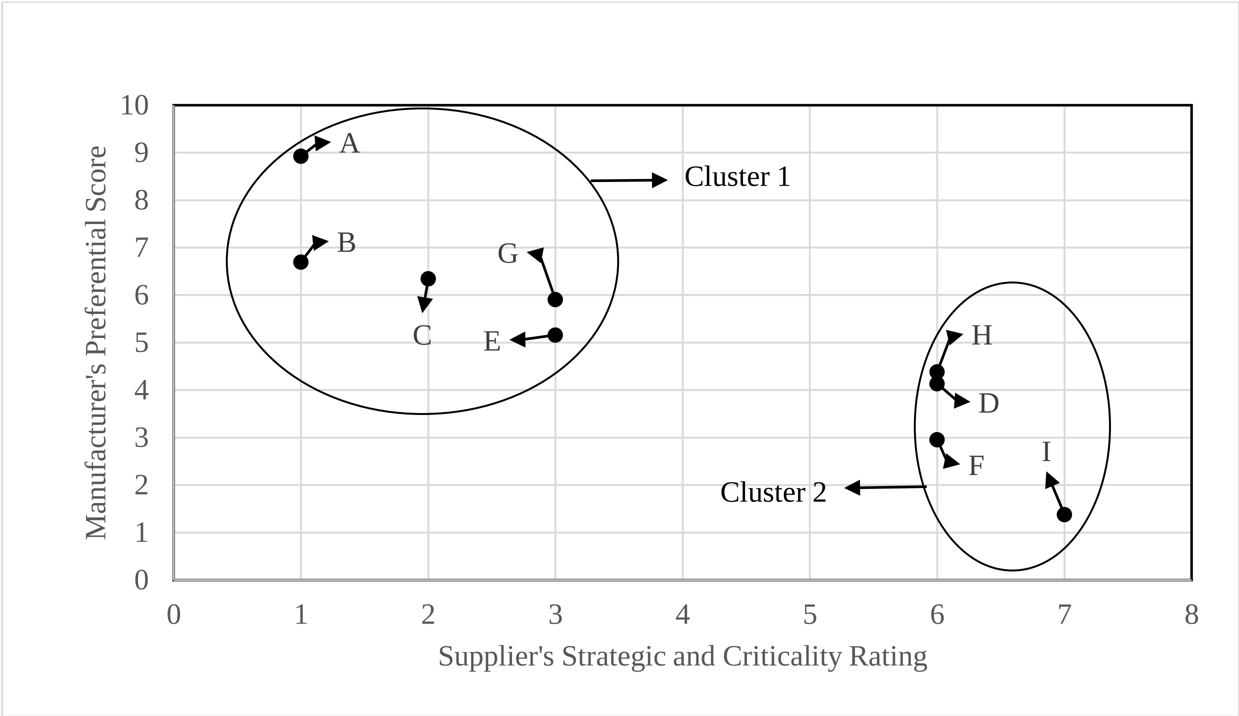


Figure 3.2.3 Supplier distribution analysis for development

-preferential status before undertaking any SD initiatives. Since SEC and CIC are more significant (as they were weighted more by suppliers) in making the manufacturer a preferred customer, Company ‘I’ should start improvement efforts using the selected attributes.

The senior executives of the company ‘I’ could relate the obtained results and have shared their consents. They found that, with the unfavorably disposed suppliers, the manufacturing personnel have to repeatedly persuade for order processing and incur heavy inspection and quality costs. The company has to relatively wait for the deliverables and experience multiplied delays propagated into its internal manufacturing systems. The suppliers were not proactive in the assistance and do not regard the intensity of loss or gain incurred by the manufacturer. They expressed that the process has efficaciously distinguished the suppliers and has provided a basis to selectively work with the suppliers. The next section discusses the managerial implications of the proposed methodology, beyond Company I’s specific results.

3.2.6 Managerial implications

While, a manufacturer should aim to become a preferred customer for its key suppliers, this must be done by leveraging the costs incurred with respect to the benefits accrued. This methodology is intended to enable a manufacturer to extract the right information from available knowledge and experiences related to key suppliers. The process developed helps a manufacturer to clearly identify the key suppliers’ dispositions towards the manufacturer. The methodology also captures information regarding the dynamics and evolution of favorable relationships with the suppliers. On the basis of this information, a manufacturer can timely work with favorably-dispositioned and underperforming suppliers and thereby can reap the advantages as well as reduce the associated difficulties. On the positive side, a manufacturer can confidently invest on the favorably-dispositioned suppliers and have sustainable relationships established. A manufacturer can also direct its investments for developing the preferential relationships with suppliers in a timely way. By applying the process at different points in time, a manufacturer can record and track suppliers' perceptions over a period of time. This data can be further used to explore the reliability of suppliers in awarding preferences and have an improved basis to promote the supplier relationships. On the negative side, a manufacturer can selectively work with underperforming suppliers and reduce the occurrences and impact of uncertainties involved in supplier management. The process, thus, enables engineering managers to revolutionize manufacturer-supplier relationships by practicing preferred customer concepts. Since the manufacturer-supplier relationships vary over a period of time, Enterprise Resource Planning (ERP) software used by the companies should be intelligent enough to understand and adapt according to the relationship dynamics. In this regard, the process may be considered as a basis to develop a module by incorporating the preferred customer concept.

3.2.7 Sectional summary

The important and strategic role of suppliers has been increasing, due to the potential benefits and limitations that suppliers impose on a supply chain. Suppliers are more inclined to offer priority (in the allocation of the best products or services) to manufacturers they perceive as preferred customers. When a manufacturer is granted with a PCS by a supplier, the manufacturer can easily establish strong supply base through SD initiatives and can create a sustainable competitive advantage over other manufacturers. Keeping this in mind, it is imperative for a manufacturer to know the level of preference ascribed by a supplier to ensure better supplies and returns on SD efforts. Thus, in this article, a methodology is proposed to facilitate a manufacturer in determining its PCS with its suppliers. In the case application described in this work, senior executives of the company found the results to be relevant and useful. In particular, as a result of the analysis, senior executives were able to evaluate the company's standing with its key suppliers. By applying the process at different points in time, the company was able to effect improvement with its suppliers. There was also a clear distinction among its suppliers on the basis of PCS offered to the company and the critical and strategic nature of the supplies. Through this the company could choose to selectively work and manage the advantages and disadvantages from its suppliers. This discretion to take advantage of certain favorably-dispositioned suppliers was important for the company's business extension plans. On the other hand, company executives could also relate their potential difficulties, e.g., wasted time in their follow-up efforts, longer waiting times, and ignorance of the loss or gain due to suppliers' activities from the unfavorably-dispositioned suppliers. Leaders expressed that such revelations about suppliers' assessment of the company as a "Preferred Customer" provide a basis to ascertain, regulate, and develop suppliers' favorable relationships with the manufacturer. If applied by other companies, the methodology can help managers to apply the preferred customer concept, plan for improvements, and confidently make business decisions about a particular supplier.

Chapter 4
Preferred Supplier Concept

4 Sectional outline

This chapter exclusively follow up on the concept of preferred customer mainly along two sections. The section 4.1 discusses about the analysis of preferred supplier enablers and the section 4.2 presents the approach for measuring the preferred supplier status.

4.1 Sectional abstract to analysis of preferred supplier enablers

A manufacturer strives to favorably associate and integrate with the good suppliers in establishing a strong supply base. Hence, usually manufacturers look for closer and favored relationships by bringing in the concept of preferred supplier while dealing with their key suppliers. This emphasis on preferential relationships has been providing a manufacturer an extra cutting-edge specifically in tackling the increased competitive pressures and reduced availability of resources. Although, the Preferred Supplier Status (PSS) ascribed to the good suppliers can fetch enormous welfare to the manufacturer's business, nonetheless most of the manufacturers do not have proper basis in implementing the concept. Thus, an approach has been followed in which the significance of various Preferred Supplier Enablers (PSEs) are determined by applying Fuzzy Analytical Hierarchy Process (FAHP) and the prominent PSEs are screened in through Pareto analysis. Also, the mutualities in between the prominent PSEs are measured by applying the Fuzzy Decision Making Trial and Evaluation Laboratory (FDEMATEL) method in order to select the right PSEs in ascribing the PSS. Finally, the weakest relationships in between the PSEs are confirmed by applying Student's t-test and an impact relation map of PSEs was developed.

4.1.1 Introduction to the analysis of PSEs

The ever increasing pressure on a manufacturer to offer competitive products/ services is forcing it to strategically get along with the best stakeholders and evolve as a competent supply chain. As a matter of fact, every stakeholder along the supply chain can create either positive or negative effect (at varying degree) on the manufacturer's business and it is becoming increasingly true with the key suppliers. Even, many manufacturers also realized the supply chain discrepancies caused by the suppliers and are confronted with the discretion to develop the suppliers either into rich assets or disregard them to repose serious repercussions. Additionally, the intensity of this divergence is further pronounced with the effect of globalization, that is to say the manufacturers not only have to deal with the domestic competition but also the competition at global level. Thus, with respect to supplier management, the manufacturers have to establish closer relationships with their key good suppliers by offering Preferred Supplier Status (PSS). This preferred supplier relationship is also called as "fit for purpose" relationship along the complex relationship dynamics between a manufacturer and its suppliers (Cox and Thompson 1997). The emphasis on selectively working with good suppliers lay down a healthy competition among the suppliers and in turn establish a good work culture (Walter et al. 2003). As there is a scarcity of good suppliers (Schiele et al. 2012), it is also essential for a manufacturer to practice the preferred supplier concept ahead of its competitors to build the best supply base. Often a manufacturer has to compete with other manufacturers to access the best of supplies and services from the same supplier and hence, it is pushed to become a preferred partner of a supplier by extending PSS. The other major reasons (which push a manufacturer to practice the preferred supplier concept) are to reduce the supply base size with few reliable suppliers and in turn reduce the associated complexities (Dorsch et al., 1998 and Sarkar and Mohapatra, 2006); to recognize and reward the qualified suppliers (Dorsch et al. 1998); and to save itself from shortage of supply and extra pricing during economic crisis as well as scarcity of resources (Carter 2000). Although, the preferred supplier concept is meritorious, it is observed that the manufacturers often ascribe preferences to the suppliers on the basis of various objectives which are intimidating and confounding in nature for the suppliers. Thus, the interdependencies between the PSEs are studied by following an approach and an attempt is made to provide a basis for a manufacturer to emphasize on the right PSEs in ascribing the preferred supplier status. In the followed approach, initially the PSEs are broadly identified under different components namely, supplier interest, common interest and supplier characteristic components. Then, Fuzzy Analytical Hierarchy Process (FAHP) is applied to determine the weights of these components as well as the PSEs under the respective components. Further, on the basis of normalized weights of all the PSEs, the prominent ones are extracted by applying Pareto analysis (80-20 rule). Subsequently, Fuzzy Decision Making Trial and Evaluation Laboratory method (FDEMATEL) is applied on these prominent PSEs to measure their interdependencies and provide a basis for a manufacturer to select the right PSEs in ascribing the PSS to the suppliers. Finally, the weakest among the obtained relationships between the PSEs from FDEMATEL are confirmed by conducting Student's t-test.

4.1.2 Literature review on the PSEs

The relationship based strategies are becoming prominent among the supply chains in order to competitively derive the best value flows among the stakeholders. In this regard, a manufacturer's practice of preferred supplier relationships has come out as an initial development for a supplier (Bemelmans et al. 2011). In answering the question: "who is a preferred supplier?", various researchers have expressed their perspectives, Dorsch et al. (1998) defines a preferred supplier as the one which is capable of constantly providing the improved product at reduced price. Wagner and Boutellier (2002) said that a manufacturer has to work with a good supplier that competitively meets its requirements beyond the letter of contract. Halley and Nollet (2002) stated that, of the types of suppliers a preferred supplier is the one who is in the best position to respond to the strategic aspirations of the buyer and who is capable of taking the pressure for enhanced supply chain flows. Recently, Acharyulu (2014) mentioned that a preferred supplier in printing industry is the one who extends the facility of credit based payments to a manufacturer. Hingley et al. (2015) mentioned that a preferred supplier is the one who takes responsibility for the entire supply chain under particular product category for maximizing the sales and profitability with an end-consumer orientation. Moreover, researchers have also ascertained the benefits that a manufacturer usually derive by practicing the preferred supplier concept. Nord (1997) demonstrated that how a buyer can accomplish the best deal through supply relationships and emphasized that a buyer must closely work with preferred supplier(s) for technology and innovation flows, especially when the supplier is dominant in the interdependence. Sieweke et al. (2012) found that, reduction of costs (including those incurred from the transactions) is the main motive for having preferred supplier programs. Supply risks and uncertainties are reduced with the preferred suppliers as a manufacturer is well experienced and aware of the suppliers (Sieweke et al., 2012). Preferred supplier relationships enhance the supply base reliability as there is reduced opportunistic behavior with a manufacturer despite the circumstances and attractions from the manufacturer's competitors (Ireland 2004). Working closely with preferred suppliers greatly reduces the lead time (transaction time, processing time, service time) and the associated costs (Robert & Monczka, 1989). Manufacturer can secure the availability of its supplies as well as the returns on its investments with the preferred suppliers (McCarthy and Golicic, 2002; and Walter et al., 2003). It can achieve preferred customer status and thereby receive prioritized supplies and services from the preferred suppliers (Williamson 1991). It can enjoy the credit based supplies/ services extended from a preferred supplier (Acharyulu 2014), which is an essential ingredient for most of the manufacturing companies in the developing countries.

By ascribing PSS, a manufacturer may provide the increased business and give priority in future business (Krause et al. 2000); make certain arrangements, favorable agreements and approvals (C. Winter 2003); increase supplier specific investments (Levina and Su 2008); offer incentives to the preferred suppliers to reduce the risks (S. Y. Tang et al. 2014); and make early payments to the preferred suppliers (Safa et al. 2014). Due to these advantages, often the suppliers demand for PSS from a manufacturer to extend their cooperation in implementing the standards such as sustainability (Grimm et al., 2012). On the other hand, the manufacturers also use PSS to insist their suppliers (Porteous et al., 2012) and set targets to the suppliers (Dharmadhikari 2012). Although PSS can bring in lot of difference in the business conducts of both manufacturer and supplier, yet in practice manufacturer's emphasis on PSEs in ascribing the PSS is often confounding to the suppliers. Moreover, there are no exclusive studies dedicated to explore the relationships between the PSEs and to select the right PSEs in ascribing PSS. Thus, in this study various PSEs mentioned in the literature along with their contextual references are mentioned in the Tables 4.1.1-4.1.3. Further, an approach has been followed using FAHP, Pareto analysis and FDEMATEL to study the interdependencies of PSEs.

Table 4.1.1 Preferred supplier enablers under manufacturer interest component

Preferred supplier enabler	References highlighted about the PSE
Supplier Loyalty (SLY)	Ruben et al. (2007); (Hüttinger et al. 2012); Mortensen and Arlbjørn (2012)
Supplier Commitment (SCT)	Caddick and Dale (1998); (R. Handfield et al. 2002); (Erdem and Göçen 2012); Baxter (2012)
Supplier Flexibility (SFL)	Erdem and Göçen (2012); Zhang et al. (2014)
Supplier Responsiveness (SRP)	Caddick and Dale (1998); Zhang et al. (2014)
Supplier Reliability (SRY)	Caddick and Dale (1998); Ruben et al. (2007)
Supplier's Environmental conscious Manufacturing (SEM)	Handfield et al. (2002); Delmas and Montiel (2009); Heikkurinen (2010)
Supplier Relationship Strength (SRS)	Wagner (2011); Friedl and Wagner (2012); Antony et al. (2012)
Supplier Pricing Structure (SPS)	Johnson (1992); Caddick and Dale (1998); Ruben et al. (2007)
Preferred Customer Perception (PCP)	Caddick and Dale (1998); Baxter (2012)
Supplier Responsibility (SRE)	Caddick and Dale (1998); Lavastre et al. (2012)
Supplier Integration Achieved (SIA)	Schiele (2012); van Blokland et al. (2013)
Supplier's Customer Satisfaction (SCS)	Wilson (1996); Baxter (2012); Zhang et al. (2014)
Supplier Performance Level (SPL)	Johnson (1992); Handfield et al. (2002); Tang (2007); Chen and Wu (2013); Zhang et al. (2014); Gosling et al. (2015)

Table 4.1.2 Preferred supplier enabler under common interest component

Preferred supplier enabler	References highlighted about the PSE
Mutual visits by Competent Personnel (MCP)	Delmas and Montiel (2009); Hüttinger et al. (2012); Nollet et al. (2012); Ellegaard and Koch (2012)
Cost Savings and Value addition (CSV)	Christiansen and Maltz (2002); Winter and Lasch (2011); Schiele et al. (2011)
Trust (TRU)	Hald et al. (2009); Dahwa et al. (2013); Yeniyurt et al. (2014); Horn et al. (2014)
Top Management Commitment from both sides (TMC)	Delmas and Montiel (2009); Schiele (2010); Nollet et al. (2012); Schiele et al. (2011); Horn et al. (2014)
Buyer-Supplier Cooperation (BSC)	Forker and Stannack (2000); Caniëls et al. (2013); Leuschner et al. (2013)
Buyer-Supplier Coordination (BCO)	Winter and Lasch (2011); Mortensen (2012); Yan and Dooley (2014)
Buyer-Supplier Collaboration (BCL)	Park et al. (2010); Najafi Tavani et al. (2013)
Buyer-Supplier Compliance (BCP)	Nollet et al. (2012); Hüttinger et al. (2012); La Rocca et al. (2012); Yeniyurt et al. (2014)
Buyer-Supplier Communication (BCM)	Ellegaard et al. (2003); Ruben et al. (2007); Delmas and Montiel (2009); Hoffmann et al. (2013)
Certifications, Listings and Accreditations (CAC)	Delmas and Montiel (2009); Hüttinger et al. (2012); Lager and Storm (2012); Arroyo-López et al. (2012)
Buyer Supplier Compatibility (BSCt)	Cox (2004); Mwikali and Kavale (2012); Arroyo-López et al. (2012)
Improvement in Ethical and Moral business values (EMB)	Ramsay and Wagner (2009); Schiele et al. (2011); Ellis et al. (2012)

Table 4.1.3 Preferred supplier enabler under supplier characteristic component

Preferred supplier’s characteristic features	References highlighted about the PSE
Supplier Proximity (SPR)	Larson and Kulchitsky (2000); Halley and Nollet (2002); Sevkli et al. (2007)
Supplier's Supplier Condition (SSC)	Lee, Kang, Hsu, et al., (2009); Routroy and Sunil Kumar (2014)
Supplier's Business History (SBH)	Choy et al. (2005); Erdem and Göçen (2012)
Supplier's Financial Capability (SFC)	Caddick and Dale (1998); Swinney and Netessine (2009); Zhang et al. (2014)
Supplier's Resource Capability (SRC)	Johnson (1992); Caddick and Dale (1998); Sevkli et al. (2007); Erdem and Göçen (2012); Zhang et al. (2014)
Supplier Reputation and Brand name (SRB)	Sevkli et al. (2007); Heikkurinen (2010); Zhang et al. (2014)
Supplier's Information Infrastructure (SII)	Caddick and Dale (1998); Larson and Kulchitsky (2000); Halley and Nollet (2002)
Supplier Project Completion capability (SPC)	Gosling et al. (2015)
Supplier's Innovation Capability (SIC)	Johnson (1992); Halley and Nollet (2002); Sevkli et al. (2007); Panayides and Venus Lun (2009); Erdem and Göçen (2012)
Supplier's Physical Distribution system (SPD)	Johnson (1992); Halley and Nollet (2002); Ruben et al. (2007)
Supplier's Facility Distribution (SFD)	Halley and Nollet (2002); Bates et al. (2012)
Supplier's Organizational Culture (SOC)	Handfield et al. (2006); Cannon et al. (2010)

4.1.3 Methodology adopted for Measuring the interdependencies of PSEs

By considering the PSEs mentioned in the previous section, FAHP is applied to determine the significance of PSEs, Pareto analysis to choose the prominent PSEs and FDEMATEL to study the interdependencies of prominent PSEs. Finally, the student's t-test was used to confirm the weakest relationships between the PSEs obtained from FDEMATEL.

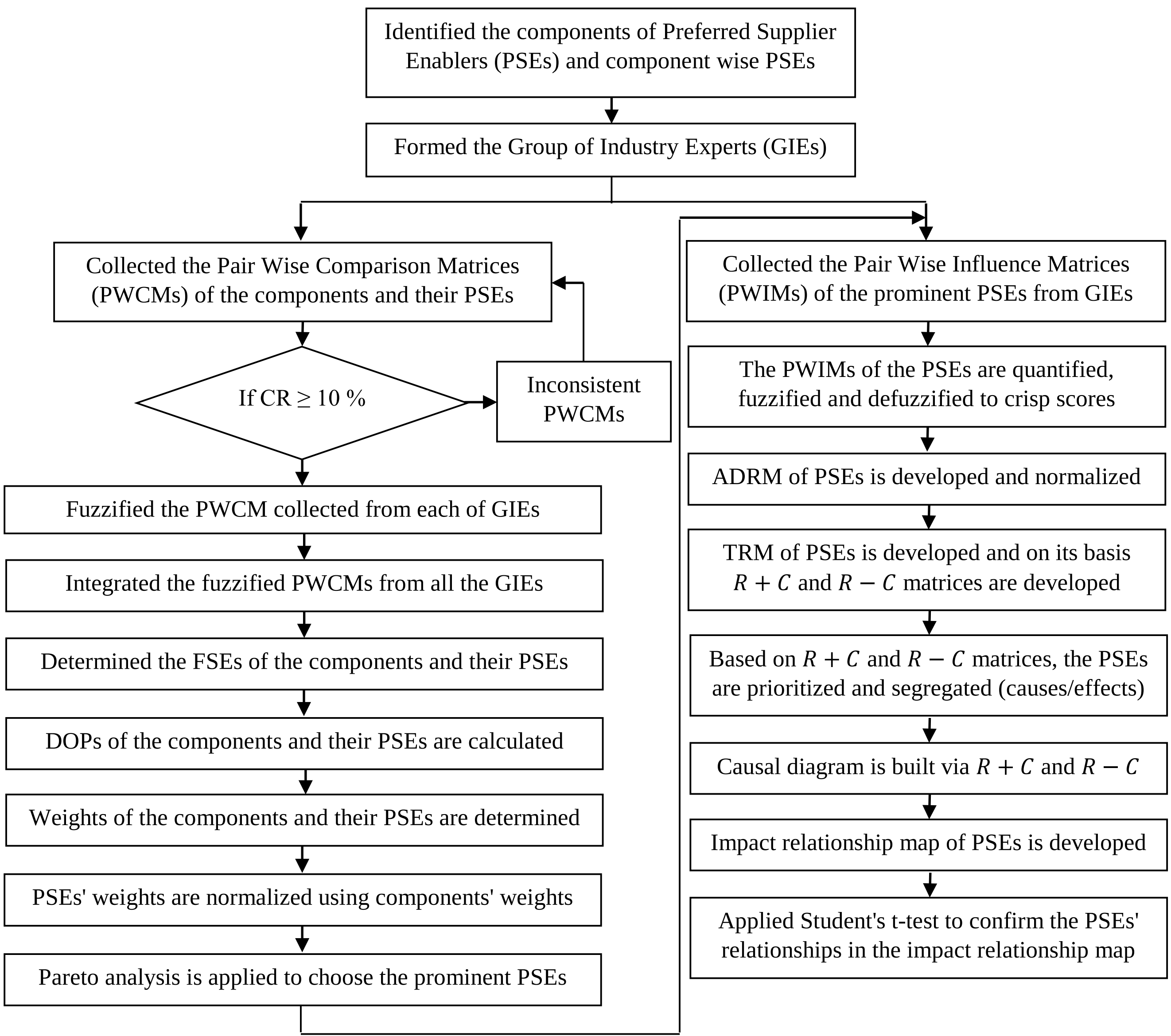


Figure 4.1.1 The approach followed to explore the interdependencies of PSEs

The whole methodology was programmed in MATLAB R2013b, with which the computational burden and the data processing time were greatly reduced. The details of the methodology are discussed in the following sections and are also summarized with the help of a flowchart shown in the Figure 4.1.1.

4.1.3.1 Data collection process

In the adopted methodology, the data collection has to be made in three phases to apply FAHP, FDEMATEL and student t-test respectively. In the first two phases, the data collection can be restricted to a group (around ten in number should be reasonably good to get the directions) of industry experts to conduct FAHP and FDEMATEL. However, in the third phase, a minimum sample of experts drawn from the same industry should be approached to get the sensible statistical confirmation. Since, here student t-test is proposed to use, at least thirty number of experts from the industry must be approached. However, larger is the sample, better is the accuracy at the expense of additional resources.

4.1.3.2 Step by step procedure for obtaining the prominent PSEs

The weights of Manufacturer Interest Component (MIC), Common Interest Component (CIC) and Supplier Characteristic Component (SCC) along with their respective PSEs can be determined by following the steps explained below:

Step 3.2.1: *Formation of Group of Industry Experts (GIEs)*

The GIEs are to be formed by drawing the experts of the industry who have in depth knowledge, skills, experience, expertise and close relation with the suppliers in extracting competitive value.

Step 3.2.2: *Construction of pair wise comparison matrices of PSEs*

Collect the relative importance between the components as well as between their corresponding PSEs in the form of Pair Wise Comparison Matrices (PWCMs) from the GIEs. These pair wise comparisons are to be made on a 1-10 scale (Saaty 1990) (See Table 4.1.4).

Table 4.1.4 Scale for pairwise comparisons (Source: Saaty (1990))

Importance measure	Definition
1	Equally important
2	Equally to moderately more important
3	Moderately more important
4	Moderate to strongly more important
5	Strongly more important
6	Strong to very strongly more important
7	Very strongly more important
8	Very to extremely strongly more important
9	Extremely more important

Step 3.2.3: Consistency check of PWCMs

Verify the consistency of PWCMs in order to ensure that the pair wise comparisons are performed without overriding the previously made opinions. For this verification, the Consistency Ratio (CR) is used as a reference and it is calculated as follows, normalize the values in each column of the PWCMs by dividing each entry with the column sum. Then, form the principal vector (PV) by taking the average of the entries along each row. If the pair wise comparison matrix is denoted as M_1, and the principal vector is denoted as M_2, then $M_3 = M_1 * M_2$ and $M_4 = M_3/M_2$. If λ_{max} is the average of the outcomes of M_4, then the consistency index *(CI)* can be calculated by, $CI = \frac{\lambda_{max} - N}{N - 1}$, where '*N*' is the number of components or the PSEs under the respective component. The Consistency Ratio *(CR)* is calculated by, $CR = \frac{CI}{RI}$, where *RI* is the random index corresponding to '*N*' (See Table 4.1.5). If the *CR* value is less than or equal to 10% (allowed percentage of error in the consistency), then the judgments made are considered to be consistent. If not, the GIEs have to improve their judgments in such a way that CR≤ 10%.

Table 4.1.5 Random Index values (Source: Saaty (2000))

Number of outcomes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Random Index	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Step 3.2.4: Fuzzification of pairwise comparison matrices from each of GIEs (Lee 2009)

The data collected in the form of PWCMs from the GIEs are fuzzified by replacing their elemental values with the corresponding TFNs (as shown in the Table 4.1.6). The TFNs corresponding to the comparison of a component/ PSE 'i' with other component/ PSE 'j' for an expert 'k' of GIEs is denoted by $(P_{ijk}, Q_{ijk}, R_{ijk})$.

Table 4.1.6 Membership functions of the fuzzy numbers (Source: (Lee (2009))

Crisp judgment of the pairwise matrix	**Triangular Fuzzy Number**
1	(1,1,2)
2	(x-1, x, x+1) for x = 2,3,…,8
9	(8,9,9)
1/1	$(2^{-1},1^{-1},1^{-1})$
1/x	$((x+1)^{-1},x^{-1},(x-1)^{-1})$ for x = 2,3,…,8
1/9	$(9^{-1},9^{-1},8^{-1})$

Step 3.2.5: Integration of fuzzified pair wise comparison matrices

The fuzzified PWCMs are integrated by means of geometric mean method by using the expressions shown below (Lee, Kang, and Chang 2009). The resultant integrated matrix constitute of the elements in TFNs denoted by (a_{ij}, b_{ij}, c_{ij}).

$$a_{ij} = \left\{ \prod_{t=1}^{s} P_{ijk} \right\}^{1/s} \quad \forall i, j = 1,2,\ldots,N$$

$$b_{ij} = \left\{ \prod_{t=1}^{s} Q_{ijk} \right\}^{1/s} \quad \forall i, j = 1,2,\ldots,N$$

$$c_{ij} = \left\{ \prod_{t=1}^{s} R_{ijk} \right\}^{1/s} \quad \forall i, j = 1,2,\ldots,N$$

Where, '*s*' denotes the number of members in the GIEs formed for the data collection.

Step 3.2.6: Determination of FSEs of components and PSEs

The FSE for each component/ PSE 'i' denoted by W_i is calculated as shown below ((Lee 2009); (Lee, Kang, and Chang 2009); (Lee, Kang, Hsu, et al. 2009) and (Chang 1996)):

$$W_i = \left(m_i^-, m_i, m_i^+ \right) = \left\{ \frac{\sum_{j=1}^{N} a_{ij}}{\sum_{i=1}^{N}\sum_{j=1}^{N} c_{ij}}, \frac{\sum_{j=1}^{N} b_{ij}}{\sum_{i=1}^{N}\sum_{j=1}^{N} b_{ij}}, \frac{\sum_{j=1}^{N} c_{ij}}{\sum_{i=1}^{N}\sum_{j=1}^{N} a_{ij}} \right\} \forall i = 1,2,\ldots,N$$

Step 3.2.7: Calculation of Degree of Possibilities

The FSE of each component/ PSE is compared with the FSEs of the rest of the components/ PSEs respectively and a value called Degree Of Possibilities (DOPs) $\mu(F_i)$ ((Chang 1996) and (Zhu et al. 1999)) are calculated as mentioned below.

$$\mu(F_2 \geq F_1) = \begin{cases} 1, & m_2 \geq m_1 \\ 0, & m_1^- \geq m_2^+ \\ \dfrac{[\, m_1^- - m_2^+]}{[(m_2 - m_2^+) - (m_1 - m_1^-)]} & otherwise \end{cases}$$

Step 3.2.8: Determination of weights

The minimum value among the DOPs ($\mu(F_i)$) of component/ PSE *'i'* will be the weight ascribed for the respective component/ PSE. By following the above procedural steps, the weights attached to the components as well as their corresponding PSEs can be obtained. Further, the weights of PSEs should be normalized with the components' weights.

Step 3.2.9: Choosing the prominent PSEs that influence PSS

The normalized PSEs obtained in the previous step must be subjected to Pareto analysis to choose the vital few PSEs on the basis of 80-20 rule.

4.1.3.3 Exploring interdependencies between PSEs

The interdependencies between the PSEs are explored by using FDEMATEL algorithm which was developed by the Science and Human Affairs Program of the Battelle Memorial Institute of Geneva between 1972 and 1976. It was used to research and solve the complicated and intertwined problem groups (Fontela and Gabus 1974). It can convert the relationships between the criteria/PSEs into a visual structural model (Hori and Shimizu, 1999; Wu and Lee, 2007; and Wu, 2008). The procedural steps of the FDEMATEL (Routroy and Sunil Kumar 2014) are detailed below**:**

Step 3.3.1 Quantification and fuzzification of linguistic responses

The same GIEs formed in the step 3.2.1 can be approached in developing the Pair Wise Influence Matrices (PWIMs) of qualitative opinions expressed in terms of linguistic responses. Transform these response matrices using a scale 0-4 (as per the influence scores field of Table 4.1.7) to get the quantified direct relationship matrices. Subsequently, fuzzify the matrices to capture the uncertainty in the experts' opinions such that the results obtained are much more accurate. To develop the fuzzified direct relationship matrices, convert the influence scores assigned to the linguistic variables into triangular fuzzy numbers as mentioned in Table 4.1.7.

Table 4.1.7 Quantification and fuzzification scale for linguistic responses

Linguistic terms	**Influence score**	**Triangular fuzzy numbers**
No influence (No)	0	(0,0,0.25)
Very low influence (VL)	1	(0,0.25,0.50)
Low influence (L)	2	(0.25,0.50,0.75)
High influence (H)	3	(0.50,0.75,1.00)
Very high influence (VH)	4	(0.75,1.00,1.00)

Step 3.3.2 Development of defuzzified direct relationship matrix of each expert of GIEs

Apply the CFCS (Converting the Fuzzy data into Crisp Scores) defuzzification method (Opricovic, 2003) to develop the Defuzzified Direct Relationship Matrix (DDRM) for each expert of GIEs. The details of CFCS are mentioned below:

(i) Normalization:

$$xr_{ij} = (r_{ij} - minl_{ij})/\Delta_{min}^{max}$$

$$xm_{ij} = (m_{ij} - minl_{ij})/\Delta_{min}^{max}$$

$$xl_{ij} = (l_{ij} - minl_{ij})/\Delta_{min}^{max}$$

$$(\text{where, } \Delta_{min}^{max} = \ max\, r_{ij} - \ min\, l_{ij})$$

(ii) Left and right spread measures of normalized fuzzy numbers,

$$xrs_{ij} = xr_{ij}/(1 + xr_{ij} - xm_{ij})$$

$$xls_{ij} = xm_{ij}/(1 + xm_{ij} - xl_{ij})$$

(iii) Compute total normalized crisp score

$$x_{ij} = \left[xls_{ij}\left(1 - \ xls_{ij}\right) + xrs_{ij} \times \ xrs_{ij}\right] / \left(1 - \ xls_{ij} + xrs_{ij}\right)$$

(iv) Compute crisp value

$$z_{ij} = \ \min l_{ij} + \ xr_{ij} \ \times \ \Delta_{min}^{max}$$

Step 3.3.3: Development of Average Direct Relationship Matrix (ADRM)

Calculate the ADRM by taking the average of all "h" DDRMs (where, h is the number of experts in GIEs).

If $z^1, z^2, z^3, \dots, z^h$ are the DDRMs obtained then ADRM (A) is obtained as shown below,

$$A = (\sum_{k=1}^{h} z^k)/h$$

The ADRM elemental values can be represented as $A = [a_{ij}]_{n \times n}$

Step 3.3.4: Normalization of Average Direct Relationship Matrix

The normalized ADRM is denoted as D. It is calculated as follows

$$D = \frac{A}{S} \; where \;\; S = \max\left(\max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}, \max_{1 \le j \le n} \sum_{i=1}^{n} a_{ij} \right)$$

Step 3.3.5: Computation of total relation matrix

$T = D(I - D)^{-1}$ where, I is the identity matrix.

$$T = [t_{ij}]_{n \times n}$$

Step 3.3.6: Prioritization (i.e. degree of importance) of PSEs

From the total relation matrix (T) obtained in the previous step, R and C matrices are formed. R represents the row sum of matrix T:

$$R = \left[\sum_{i=1}^{n} t_{i1} \sum_{i=1}^{n} t_{i2} \dots \sum_{i=1}^{n} t_{ij} \dots \sum_{i=1}^{n} t_{in} \right]$$

(where, j represents the row number, i represents column number and n represents number of rows or columns of matrix T, since T is a square matrix). Similarly, C represents column sum of matrix T:

$$C = \left[\sum_{j=1}^{n} t_{1j} \sum_{j=1}^{n} t_{2j} \ldots \sum_{j=1}^{n} t_{ij} \ldots \sum_{j=1}^{n} t_{in}\right]$$

From R and C matrices, determine the $R + C$ matrix (where each element of the matrix indicates the degree of importance of the corresponding enabler) and prioritize the enablers.

Step 7: *Segregation of PSEs into cause and effect groups*

Determine the $R - C$ matrix from R and C matrices obtained in the previous step. The positive signed elements indicate that the corresponding enablers are causes and negative elements indicate effects.

Step 8: *Development of causal diagram*

Develop a causal diagram for the PSEs by taking their $\mathrm{R + C}$ and $\mathrm{R - C}$ values along X-axis and Y-axis respectively.

Step 9: *Development of impact relationship map*

Determine the threshold value by taking the average of elements in the TRM and deduct it from the TRM elements to filter out the insignificant interdependencies. In fixing the threshold value the GIEs' opinions must also be taken into consideration. After deducting the threshold value from all the elements of TRM, the relationships between the PSEs having negative values can be safely ignored to determine the reduced TRM. From this reduced TRM, the relationships from effects (see step 7) to causes as well as those in between the causes can also be deleted (as their contribution would be less) to obtain the Final Control Matrix (FCM) of PSEs. Then, the Pareto analysis has to be applied on relationships of PSEs in FCM in order to extract weakest interdependencies. These weakest interdependencies between the PSEs are to be confirmed by applying simple student t-test. After confirming the interdependencies between the PSEs, the concise impact relationship map of PSEs can be developed.

4.1.3.4 Student's t-test

In order to confirm the weakest interdependencies between the PSEs, a student's t-test can be applied by collecting the data about the strength of interdependencies on a Likert scale of 1 to 5 (1-very low, 2-low, 3-medium, 4-high, and 5-very high) from a sample of industry experts. The collected data has to be compared against a test mean of 3.5 to ensure stronger relationship between the PSEs. Since, the critical area of distribution is one directional, the one tailed t-test is more suitable in this case. In conducting this one tailed t-test, larger the t-statistic value indicates higher the chance of rejecting the null hypothesis. If the t-value is greater than the critical t-value then the null hypothesis can be rejected. Depending upon a decision maker's choice, the test can be conducted at any percentage level of confidence (if it is conducted at 95% confidence level and n=30 then α value will be 0.05 and t-critical $_{(\alpha = 0.05,\ df = 29)}$ = 1.699127).

4.1.4 Application process of the methodology

In this study the electronic manufacturing industry was specifically preferred, as the suppliers' role in the industry has been relatively prominent due to high agility in the manufacturing systems. The key suppliers' contribution especially in terms of innovation flow is very eminent and an important success factor for the electronic manufacturing supply chains. Moreover, their highly compressed product life cycles, high demand uncertainties, increasingly demanding customers and competitively available alternatives altogether justify the choice of application. As per the procedural steps mentioned in the previous section, a group of ten experts (who are all designated in the top managerial positions) from the electronic manufacturing industry in India were approached to apply FAHP and FDEMATEL. They were explained about the purpose of the study along with the expected inputs, outcomes and utilities. During the process of data collection, the GIEs were coordinated on the internet by sharing the excel sheets related to the study. The lists of

PSEs under MIC, CIC and SCC were shared with the GIEs to get their nod on the relevancy of PSEs. Under FAHP, the GIEs were asked to fill out the PWCMs and they were further checked for consistency. The consistent PWCMs were then fuzzified and integrated to determine the FSEs of components/ PSEs. On the basis of these FSEs, the DOPs in relation to other component/ PSEs were calculated and the minimum of which is taken as the weight of a component/ PSE (see Table 4.1.8). From the obtained weights of components, the weights of PSEs were normalized and Pareto analysis was conducted on the normalized weights to choose the prominent PSEs (see Figure 4.1.2). These prominent PSEs were inputted to FDEMATEL to explore their interdependencies. According to the steps detailed in the section 3.3, the GIEs were asked to express their opinions regarding the influence one PSE over the other in the form of PWIMs. These PWIMs from GIEs were further quantified (DRMs) and fuzzified (FDRMs). Then, as detailed in the step 3.3.2, the CFCS defuzzification method was used to obtain the crisp influence scores of PSEs in the form DDRMs. These DDRMs were further averaged to obtain ADRM and then it was normalized to obtain the matrix 'D'. On the basis of this matrix 'D', the TRM was computed according to the step 3.3.5 (see Table 4.1.9). By taking the sum of rows and columns of TRM, the 'R' and 'C' matrices were calculated and then $R + C$ and $R - C$ matrices were constructed (see Table 4.1.10 and Table 4.1.11). As discussed before, an element corresponding to a PSE in $R + C$ matrix indicates its prominence while an element of $R - C$ matrix indicates the group (i.e. cause and effect) to which a PSE belongs. Further, on the basis of elemental values in $R + C$ and $R - C$ matrices, a causal diagram was developed to graphically present the distribution of PSEs with respect to their prominence among cause and effect groups. In the causal diagram (see Figure 4.1.3), the PSEs above the zero line indicate cause group while those below the zero line indicate the effect group. Then, the average of TRM was taken as the threshold value and it was deducted from the elements of TRM to obtain the significant TRM (Table 4.1.12). After deleting the relationships falling below the threshold value, the FCM of PSEs was obtained (Table 4.1.13). Then, the Pareto analysis was applied on the relationships between the PSEs of FCM to obtain the weakest relationships. Totally, 19 weakest relationships between the PSEs were considered for statistical confirmation. For this a sample of 30 experts from the electronic manufacturing industry were approached to confirm the relationships by using student's one tailed t-test at 95% confidence interval. The hypotheses constructed in conducting the t-test are shown below,

H_o: $\mu_{sample} - \mu_{test} = 0$ (i.e. the strength of relationship falls below the test mean)

H_1: $\mu_{sample} - \mu_{test} > 0$ (i.e. the strength of relationship falls above the test mean)

Table 4.1.14 shows the various questions asked in testing the weakest interdependencies between the PSEs. Finally, an impact relationship map was developed on the basis of FCM by eliminating those relationships which are rejected after conducting the t-test (see Figure 4.1.4). The obtained results and their interpretation are discussed in detailed in the next section.

Table 4.1.8 Weights of components along with their respective PSEs

MIC Component (Weight 0.507)		CIC Component (Weight 0.34)		SCC Component (Weight 0.153)	
PSE	**Weight**	**PSE**	**Weight**	**PSE**	**Weight**
SLY	0.08	MCP	0.118	SPR	0.126
SCT	0.078	CSV	0.137	SSC	0.081
SFL	0.097	TRU	0.137	SBH	0.078
SRP	0.072	TMC	0.115	SFC	0.051
SRY	0.097	BSC	0.054	SRC	0.076
SEM	0.005	BCO	0.045	SRB	0.146
SRS	0	BCL	0.019	SII	0.072
SPS	0.127	BCP	0.114	SPC	0.069
PCP	0.117	BCM	0.117	SIC	0.146
SRE	0.132	CAC	0.01	SPD	0.065
SIA	0.064	BSCt	0.069	SFD	0.06
SCS	0.01	EMB	0.065	SOC	0.03
SPL	0.123				

Table 4.1.9 Total relationship matrix of PSEs

PSE	SRE	SPS	SPL	PCP	SFL	SRY	CSV	TRU	SLY	MCP	BCM	SCT	TMC	BCP	SRP	SIA	BSCt	SRB
SRE	0.044	0.015	0.013	0.058	0.011	0.088	0.008	0.015	0.006	0.004	0.002	0.007	0.002	0.007	0.004	0.001	0.054	0.000
SPS	0.093	0.087	0.031	0.128	0.021	0.016	0.102	0.097	0.008	0.010	0.064	0.002	0.008	0.010	0.008	0.082	0.005	0.000
SPL	0.085	0.099	0.120	0.023	0.128	0.015	0.011	0.015	0.005	0.059	0.009	0.003	0.005	0.002	0.059	0.008	0.004	0.000
PCP	0.094	0.114	0.108	0.029	0.026	0.028	0.113	0.117	0.004	0.020	0.015	0.003	0.010	0.079	0.059	0.009	0.005	0.000
SFL	0.063	0.001	0.003	0.004	0.114	0.005	0.001	0.001	0.000	0.000	0.000	0.000	0.031	0.000	0.000	0.000	0.003	0.000
SRY	0.094	0.034	0.089	0.033	0.122	0.110	0.017	0.069	0.070	0.041	0.008	0.087	0.012	0.033	0.006	0.003	0.005	0.000
CSV	0.068	0.059	0.004	0.019	0.003	0.007	0.012	0.009	0.002	0.029	0.055	0.001	0.001	0.002	0.001	0.004	0.004	0.000
TRU	0.089	0.068	0.098	0.020	0.110	0.068	0.011	0.016	0.008	0.060	0.005	0.007	0.080	0.003	0.006	0.005	0.005	0.000
SLY	0.093	0.106	0.107	0.073	0.060	0.070	0.072	0.049	0.034	0.012	0.010	0.006	0.059	0.008	0.009	0.008	0.005	0.000
MCP	0.106	0.031	0.031	0.117	0.022	0.052	0.020	0.095	0.060	0.009	0.005	0.033	0.011	0.010	0.008	0.002	0.006	0.000
BCM	0.120	0.019	0.012	0.110	0.004	0.012	0.113	0.014	0.001	0.005	0.007	0.001	0.001	0.009	0.006	0.001	0.006	0.000
SCT	0.114	0.124	0.120	0.138	0.145	0.105	0.114	0.033	0.113	0.015	0.067	0.037	0.012	0.013	0.013	0.009	0.006	0.000
TMC	0.115	0.008	0.059	0.008	0.092	0.010	0.029	0.003	0.001	0.004	0.002	0.001	0.003	0.001	0.004	0.001	0.006	0.000
BCP	0.090	0.080	0.084	0.123	0.027	0.124	0.021	0.058	0.012	0.064	0.007	0.011	0.006	0.013	0.011	0.006	0.005	0.000
SRP	0.079	0.092	0.068	0.022	0.018	0.091	0.016	0.015	0.007	0.007	0.058	0.007	0.002	0.004	0.005	0.007	0.004	0.000
SIA	0.092	0.110	0.131	0.102	0.106	0.016	0.026	0.023	0.080	0.010	0.036	0.002	0.009	0.008	0.012	0.008	0.005	0.000
BSCt	0.068	0.113	0.009	0.017	0.008	0.010	0.011	0.063	0.002	0.004	0.007	0.001	0.005	0.002	0.001	0.009	0.004	0.000
SRB	0.068	0.084	0.058	0.029	0.061	0.049	0.045	0.070	0.039	0.014	0.013	0.033	0.062	0.032	0.008	0.035	0.032	0.028

Table 4.1.10 Significance of PSEs

PSEs	SPS	SRE	PCP	SPL	SRY	SCT	TRU	SFL	SLY	CSV	MCP	BCP	SIA	BCM	SRB	SRP	TMC	BSCt
R+C	2.016	1.912	1.88	1.795	1.709	1.421	1.418	1.306	1.23	1.023	0.985	0.974	0.971	0.812	0.788	0.721	0.665	0.492
Ranking	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Table 4.1.11 Grouping of PSEs into effects and groups

PSEs	SRE	SPS	SPL	PCP	SFL	SRY	CSV	TRU	SLY	MCP	BCM	SCT	TMC	BCP	SRP	SIA	BSCt	SRB
R-C	-1.235	-0.470	-0.494	-0.222	-0.850	-0.045	-0.464	-0.103	0.331	0.249	0.074	0.938	0.029	0.504	0.281	0.575	0.170	0.732
Grouping	Effects								Causes									

Table 4.1.12 Significant TRM of PSEs

PSE	SRE	SPS	SPL	PCP	SFL	SRY	CSV	TRU	SLY	MCP	BCM	SCT	TMC	BCP	SRP	SIA	BSCt	SRB
SRE	0.010	0.000	0.000	0.024	0.000	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000
SPS	0.059	0.053	0.000	0.094	0.000	0.000	0.068	0.063	0.000	0.000	0.030	0.000	0.000	0.000	0.000	0.048	0.000	0.000
SPL	0.051	0.065	0.086	0.000	0.094	0.000	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.025	0.000	0.000	0.000
PCP	0.060	0.080	0.074	0.000	0.000	0.000	0.079	0.082	0.000	0.000	0.000	0.000	0.000	0.044	0.024	0.000	0.000	0.000
SFL	0.029	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SRY	0.060	0.000	0.054	0.000	0.088	0.076	0.000	0.035	0.036	0.007	0.000	0.053	0.000	0.000	0.000	0.000	0.000	0.000
CSV	0.034	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TRU	0.055	0.034	0.064	0.000	0.076	0.033	0.000	0.000	0.000	0.026	0.000	0.000	0.046	0.000	0.000	0.000	0.000	0.000
SLY	0.059	0.072	0.073	0.039	0.026	0.036	0.038	0.015	0.000	0.000	0.000	0.000	0.025	0.000	0.000	0.000	0.000	0.000
MCP	0.072	0.000	0.000	0.083	0.000	0.018	0.000	0.061	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BCM	0.086	0.000	0.000	0.076	0.000	0.000	0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SCT	0.080	0.090	0.086	0.104	0.111	0.071	0.080	0.000	0.079	0.000	0.033	0.003	0.000	0.000	0.000	0.000	0.000	0.000
TMC	0.081	0.000	0.025	0.000	0.058	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BCP	0.056	0.046	0.050	0.089	0.000	0.090	0.000	0.024	0.000	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SRP	0.044	0.058	0.034	0.000	0.000	0.057	0.000	0.000	0.000	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SIA	0.057	0.076	0.097	0.067	0.072	0.000	0.000	0.000	0.046	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BSCt	0.034	0.079	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SRB	0.034	0.049	0.024	0.000	0.027	0.015	0.011	0.035	0.004	0.000	0.000	0.000	0.028	0.000	0.000	0.000	0.000	0.000

Table 4.1.13 Final control group matrix of PSEs

PSE	SRE	SPS	SPL	PCP	SFL	SRY	CSV	TRU
SLY	0.059	0.072	0.073	0.039*	0.026*	0.036*	0.038*	0.015*
MCP	0.072	0.000	0.000	0.083	0.000	0.018*	0.000	0.061
BCM	0.086	0.000	0.000	0.076	0.000	0.000	0.079	0.000
SCT	0.080	0.090	0.086	0.104	0.111	0.071	0.080	0.000
TMC	0.081	0.000	0.025*	0.000	0.058	0.000	0.000	0.000
BCP	0.056	0.046*	0.050	0.089	0.000	0.090	0.000	0.024*
SRP	0.044*	0.058	0.034*	0.000	0.000	0.057	0.000	0.000
SIA	0.057	0.076	0.097	0.067	0.072	0.000	0.000	0.000
BSCt	0.034*	0.079	0.000	0.000	0.000	0.000	0.000	0.029*
SRB	0.034*	0.049*	0.024*	0.000	0.027*	0.015*	0.011*	0.035*

(Note: * - indicates weakest interdependence between the PSEs)

Table 4.1.14 Results obtained after hypotheses testing of interdependencies

Question asked	Link	t-value	P-value	Mean	Remark
Supplier loyalty enhances preferred customer perception	SLYPCP	10.770	0.000	4.500	Accept
Supplier loyalty enhances cost savings and value addition	SLYCSV	5.214	0.000	4.000	Accept
Supplier loyalty enhances its flexibility	SLYSFL	2.350	0.013	3.700	Accept
Supplier loyalty enhances its reliability	SLYSRY	2.842	0.004	3.733	Accept
Supplier loyalty improves trust factor	SLYTRU	3.084	0.002	3.833	Accept
Mutual visits by competent personnel improves supplier reliability	MCPSRY	2.570	0.008	3.767	Accept
Top management commitment improves performance level	TMCSPL	4.558	0.000	3.900	Accept
Buyer-supplier compliance improves trust factor	BCPTRU	5.277	0.000	3.933	Accept
Supplier responsiveness improves its responsibility	SRPSRE	4.039	0.000	3.800	Accept
Supplier responsiveness has effect on its performance level	SRPSPL	4.557	0.000	3.933	Accept
Buyer-supplier compatibility leads to improved responsibility	BSCtSRE	-7.919	1.000	2.833	Reject
Buyer-supplier compatibility enhances trust factor	BSCtTRU	1.838	0.038	3.700	Accept
Supplier reputation and brand name results in improved pricing structure	SRBSPS	4.157	0.000	3.967	Accept
Supplier reputation and brand name improves trust factor	SRBTRU	3.515	0.001	3.867	Accept
Supplier reputation and brand name makes it responsible	SRBSRE	5.442	0.000	3.900	Accept
Supplier reputation and brand name improves its flexibility	SRBSFL	-12.092	1.000	2.400	Reject
Supplier reputation and brand name improves its performance level	SRBSPL	-0.955	0.826	3.367	Reject
Supplier reputation and brand name enhances its reliability	SRBSRY	-0.881	0.807	3.400	Reject
Supplier reputation and brand name improves cost savings and value addition	SRBCSV	-0.643	0.737	3.433	Reject

4.1.5 Results and discussions

As discussed in the previous section, FAHP was applied to determine the significance of components/ PSEs in terms of weights. From Table 4.1.8, it can be seen that MIC, CIC and SCC got 0.507, 0.34 and 0.153 weights respectively. It means that PSEs under MIC component should be given more importance followed by CIC and SCC. As discussed before, the Pareto analysis was applied on the normalized weights of PSEs and on the principle of 80-20 rule, 18 PSEs were chosen as prominent out of 36 PSEs (see Figure 4.1.2). Further, these 18 PSEs were considered for further analysis using FDEMATEL to explore the interdependencies between the PSEs. The TRM obtained during the execution of procedural steps of FDEMATEL is shown in the Table 4.1.9, this represents the overall relationships between the PSEs. From this TRM, the $R + C$ and $R - C$ matrices were calculated and are shown in the Table 4.1.10 and Table 4.1.11 respectively. As discussed earlier, the elements of $R + C$ matrix indicate the significance of PSEs and hence, higher the $R + C$ value of a PSE, larger is the significance. Thus, from Table 4.1.10, it can be said that the better ranked PSEs on the basis of $R + C$ values can be sought as prominent ones. On the other hand, $R - C$ values indicate the direction of prominence and characterize a PSE into either a cause or an effect (Table 4.1.11 shows the grouping of PSEs into causes and effects). On the basis of these $R + C$ and $R - C$ matrix values, the PSEs were plotted on a causal diagram as shown in the Figure 4.1.3. From causal diagram, it can be inferred that a manufacturer can primarily start choosing to focus on improving the PSEs with high prominence (i.e. SCT, SLY, MCP, BCP, and SIA) and monitor the most prominent effects (i.e. SPS, SRE, PCP, SPL and SRY). Further, the average of TRM elements i.e. 0.034134 was taken as threshold value and it was deducted from the TRM elements to obtain the reduced TRM shown in the Table 4.1.12 (the negative signed elements are replaced with zeros). With reference to the causal diagram, the FCM was formed by eliminating the relationships between the causes and those from effects to causes. After applying Pareto analysis on the relationships between the PSEs of FCM, nineteen weakest relationships were considered for statistical confirmation. In order to confirm these nineteen relationships, a questionnaire was developed and circulated to 30 experts from the electronic industry to capture the degree of agreement regarding the relationship between the PSEs on a scale of 1-5. The sample mean was tested against a test mean by using one tailed student’s t-test. The observed statistics and the corresponding remarks related to the acceptance/ rejection of the hypothesis are mentioned in the Table 4.1.14. It can be see that, five out of nineteen links were rejected on the basis of experts’ opinions those which are falling below the t-critical value. On the basis of FCM and by only retaining the statistically confirmed relationships an impact relationship map (see Figure 4.1.4) was developed. This relationship map their corresponding strengths would enable a manufacturer to clearly know the cause PSEs and their corresponding effect PSEs.

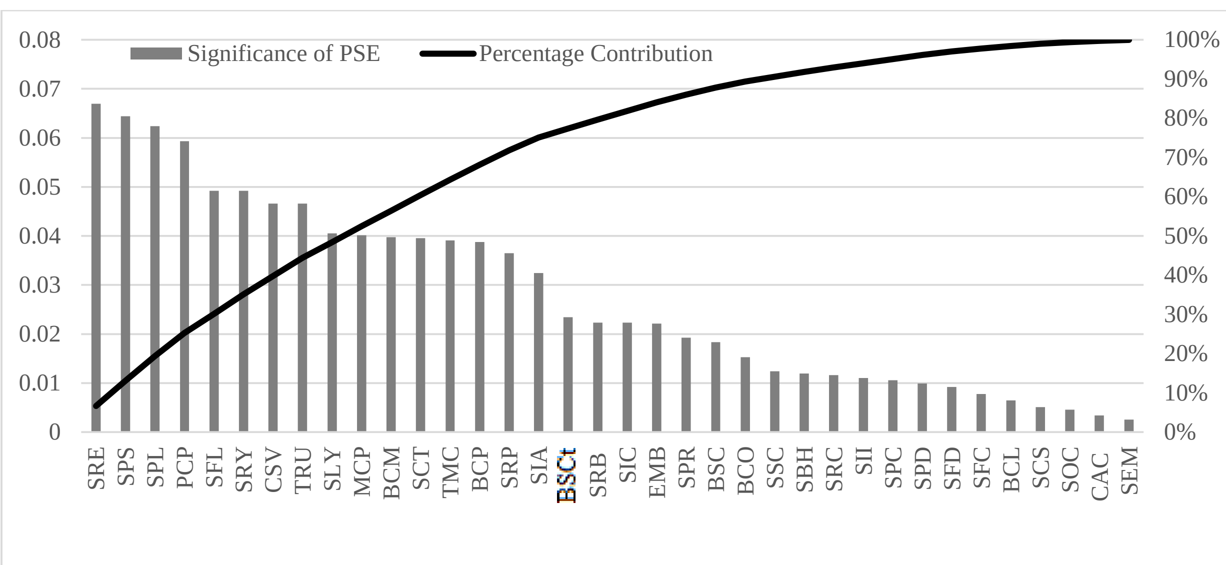


Figure 4.1.2 Pareto analysis to extract the prominent PSEs

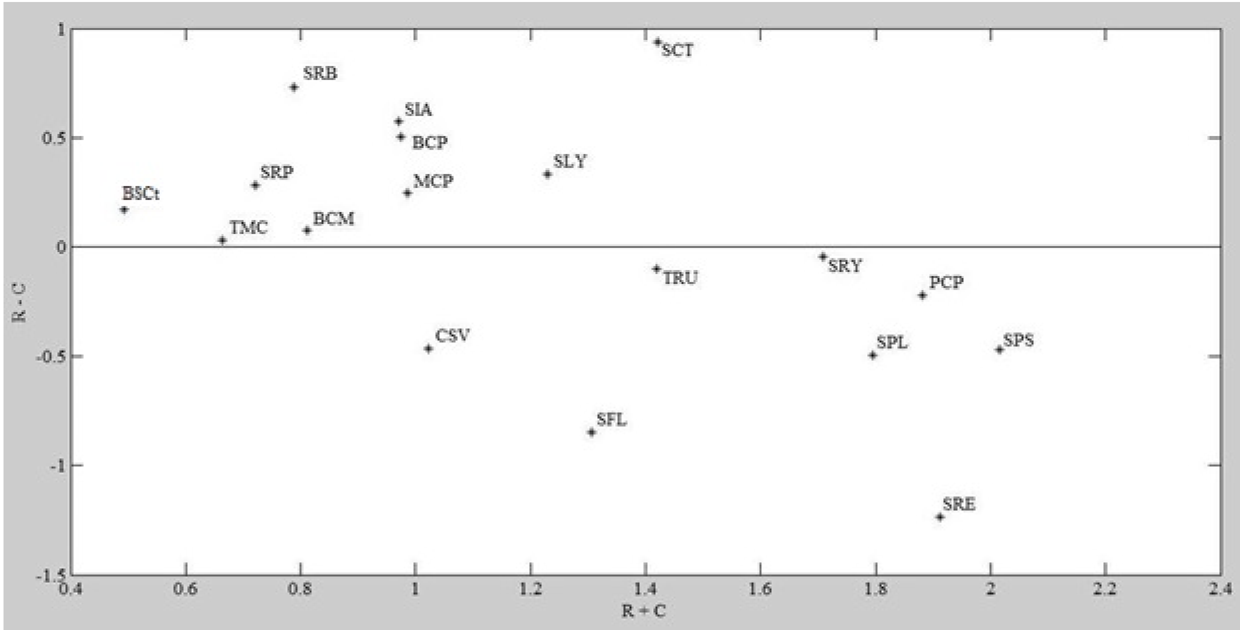


Figure 4.1.3 Causal diagram of prominent PSEs

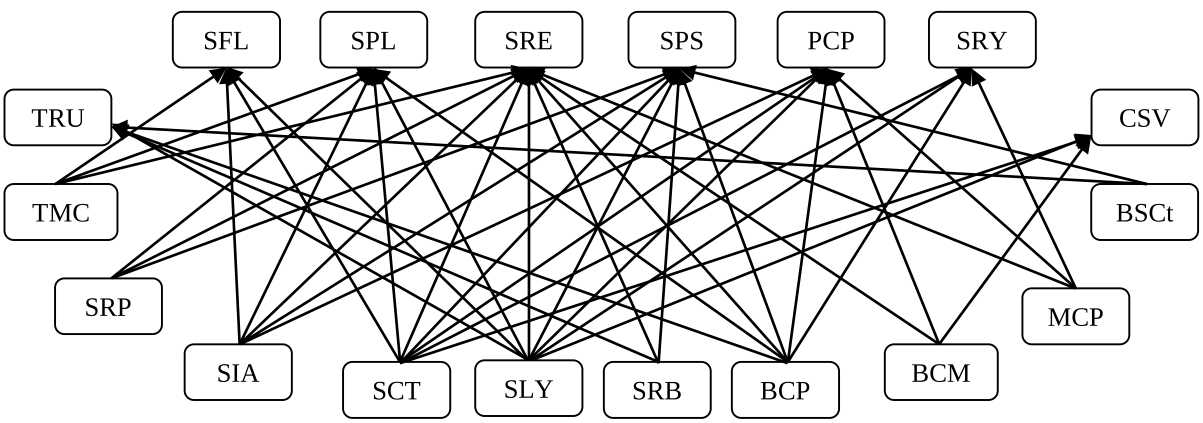


Figure 4.1.4 The final impact relationship map of PSEs

4.1.6 Sectional summary

In the current scenario of relationship based competition among the manufacturing supply chains, the preferential relationships with good stakeholders would empower a manufacturer to stay at an advantage along the highs and lows of business. In this respect, a manufacturer adopts preferred supplier concept with few of its good suppliers in order to ensure prioritized supplies/ services and to maximize the supply chain flows from the suppliers. Although, developing preferred relationships would benefit a manufacturer's business, yet most of the manufacturers do not have proper basis in ascribing the PSS. Thus, an approach has been followed to explore the interdependencies between the PSEs and extract the right ones to emphasize. Initially, several PSEs were broadly identified under three components namely MIC, CIC and SCC. Then, FAHP was applied to determine the significance of the components as well as the PSEs under the respective components. It was found that MIC is given more importance in ascribing PSS to the suppliers. Based on the obtained weights of components and PSEs, a Pareto analysis was conducted to choose the prominent PSEs in ascribing PSS (see Figure 4.1.2). Further, FDEMATEL was applied on the prominent PSEs to explore the interdependencies between the PSEs. By applying FDEMATEL, the strength of relationships between the PSEs, grouping of PSEs into causes and effects on a causal diagram and a concise impact relationship map of PSEs were obtained. On the basis of causal diagram (see Figure 4.1.3), it was inferred that a manufacturer must primarily start focusing on the PSEs with high prominence (i.e. SCT, SLY, MCP, BCP, and SIA) and monitor the most prominent effects (i.e. SPS, SRE, PCP, SPL and SRY). In order to confirm the weakest among the obtained relationships between the PSEs, a one tailed student's t-test was conducted. After eliminating the rejected links, the final impact relationship map was developed (see Figure 4.1.4), with which a manufacturer can clearly visualize the cause PSEs (located at the bottom of the map) and their corresponding effect PSEs (located at the bottom of the map). It must be noted that the obtained results are specifically related to the electronic industry in India. However, the same approach followed in this study can be applied for other industries and also in different contexts.

4.2 Sectional abstract to measuring preferred supplier status

The purpose of this section is to assist a manufacturer with a process to measure the level of Preferred Supplier Status (PSS) of its key suppliers along the timeline. In this regard, for measuring the PSS, the prominent Preferred Supplier Enablers (PSEs) were identified and were broadly categorized under manufacturer's interest component, common interest component and supplier's characteristic component. These PSEs were further analyzed by using fuzzy analytic hierarchy process, Euclidean distance measurement and grey relation analysis methods. In order to demonstrate the application and utility of the proposed approach, a case study conducted in an Indian automotive component manufacturing company has been presented. To mention the findings: by applying the proposed methodology in a case company, the PSSs of five of its key suppliers were measured and then the suppliers' characteristic scores were determined. Based on these scores, a preferential status plot of the suppliers was developed. Through the status plot, the manufacturer was suggested with whom the proposed initiatives can be productive and with whom the manufacturer has to appeal for improvement strategies. To mention the research implications: since the methodology was tried in the Indian manufacturing environment, the emphasis laid on the PSEs and in turn the measurement of PSS may not address the concern at large. To talk about the practical implications, measuring PSS would not only earn competitive advantages for the manufacturers but also facilitate the evolution of competitive suppliers. To highlight the originality: measuring PSS along the time would assist a manufacturer to effectively manage the preferences given to its suppliers and thereby enhance the supply base contribution in the value addition process.

4.2.1 Introduction to measuring preferred supplier status

Since the competition has been extended from enterprises to Supply Chains (SCs), the manufacturers are focusing to have preferred SC partners. Especially, the emphasis to have stronger supply base has been growing to counter supply uncertainties and reap competitive advantages from the suppliers (Rees, 2011). As a result of this, traditionally those suppliers whose contribution in the value addition process was down valued are now given strategic roles to play. Most of the organizations now have various supply management practices such as mapping customer requirements with suppliers, supplier profile generation, supplier selection, supplier contract management, supplier evaluation, supplier development, supplier integration, and supplier benchmarking (Monczka et al., 2008). Of these supply management practices, supplier selection is considered to be the most influential on the SC performance (Koufteros et al., 2012). In this regard, Kahraman et al. (2003) said about supplier selection in a simpler manner as comparing the suppliers along a set of common criteria with an overall goal to select the high-potential suppliers. Şen et al. (2010) highlighted the prequalification of potential suppliers along with the phases of problem definition and formulation of criteria and provided a holistic point of view in the supplier selection process. An appropriate supplier selection method would definitely help a manufacturer to choose a right supplier, but in practice much of the challenges and potentialities are experienced and explored after partnering with a supplier. So as to overcome these issues, various supplier evaluation methods are floated in research and even regularly practiced by the companies. Followed by evaluation, a manufacturer may resort to supplier switching or supplier development or acquiring supplier technology in-house and/ or combination of these (Kumar Pradhan and Routroy, 2014).

Further, in carrying out the supply management activities the manufacturers often choose to have multiple suppliers for increasing reliability, to mitigate the supply uncertainties and to avoid monopoly of a single supplier (Thun et al., 2011). However, in order to avoid multiplied complexities and to ensure strong supply base, manufacturers aspire to work with few reliable suppliers (Lee, 1995; Caddick & Dale, 1998; Dorsch, Swanson, & Kelley, 1998; and Costantino & Pellegrino, 2010). Cox (2001) also pointed out the significance of directing resources on limited number of Preferred Suppliers (PSs) in the integrated SC management approach. Although the key suppliers' role has got a strategic position to play, not all the suppliers are/ must be equally preferred by the manufacturer. Often a supplier importance to a manufacturer is decided based on the extent to which the manufacturer's interests are fulfilled and the appropriateness in the suppliers' characteristics. These aspects inherently led to the practice of Preferred Supplier Status (PSS) concept among the manufacturers. Moreover, PS system has become one of the instituted changes in updating the procurement departments across various organizations (Ivarsson and Alvstam, 2010). By ascribing PSS to the suppliers, the manufacturers tend to relatively become favorably disposed with few suppliers. The PS programs are put forth by the manufacturers mainly but not limited to increase the morale of the relatively best performing suppliers and thereby encourage them to continuously perform as per manufacturer's requirements; provide benchmarking targets for other suppliers (i.e. who are relatively lagging behind) and spur competitive spirit among the suppliers to achieve PSS (Lee, Kang and Chang, 2009); to attract the PSs and to have long term business relationships established with them; and to reduce the risk of supplier's opportunistic behavior and secure its investments (Ruben, Boselie, & Lu, 2007; and Cannon, Doney, Mullen, & Petersen, 2010). Having discussed about the PSS, the current study presents an approach for a manufacturer's assistance to measure the PSS of its key suppliers along the timeline (i.e. past, present and target states).

4.2.2 Literature review on preferred supplier concept

The preferred supplier is relatively a well-posited supply partner in understanding and delivering further than the just requirements of a manufacturer (Halley and Nollet, 2002). The major reasons that push a manufacturer towards its suppliers include but not limited to manufacturers' preference to become less vertically integrated in order to focus on their core competencies (Routroy and Sunil Kumar, 2014); to have the industry best standards and practices adopted through specialized suppliers' knowledge and expertise (Ellis et al., 2012); to achieve competitive advantages (viz. cost reduction, quality improvement, lead time reduction, and breeding innovation) by associating with the dedicated partner (Halley & Nollet, 2002; Ruben et al., 2007; and Sieweke, Birkner, & Mohe, 2012); to become resilient to the external influences like economic crisis, political uncertainty, changing policies, rules and regulations (Carvalho et al., 2012); to face SC disruptions due to environmental disasters (Yilmaz-Börekçi et al., 2014); to reduce the opportunistic behavior of the suppliers (Petison and Johri, 2008); to compress the lead time as well as after sale service time (Larson and Kulchitsky, 2000); to face the challenge of reduced product life cycles (Halley & Nollet, 2002; and Hock Soon & Mohamed Udin, 2011); to attract and satisfy the increasingly demanding customers (Booth, 2014); to face the increased competition in providing or capable of providing similar kind of advantages in the products/ services (Moore and Manring, 2009); to gain contract incentives from the suppliers (Rees, 2011); to ensure product availability and to protect bargaining power (Tang, 2007); and to reengineer the manufacturing systems as per lean, agile, le-agile and green manufacturing principles (Moore and Manring, 2009). While on the other hand from the suppliers' side, the want for becoming PS subsists to ensure long term collaboration with the manufacturer (Cannon et al., 2010; and Sieweke et al., 2012), internal cost reduction (Ellis et al., 2012), increase sales (Corbett et al., 2012), gain assistance and learning opportunities (Ramsay & Wagner, 2009; and Dries, Germenji, Noev, & Swinnen, 2009), improve investments and timely payments (Dries et al., 2009), draw reputation benefits (Gil, 2009), secure smooth relationship with the manufacturer (Dries et al., 2009; and Sieweke et al., 2012); gain more business as well as economies of scale from the manufacturer (Ruben et al., 2007; and Tang, 2007) and benefit through managerial and technical support (Petison and Johri, 2008). Thus, along this concept of PSS, on one hand manufacturers orients towards the PSs and on other hand suppliers wish to achieve PSS.

Although the concept of PS was brought out in 1970s', the regular research on this topic was started from 1990's. While PSS was mentioned by many researchers, only few objective studies dealing with the PSS concept are available in the published literature. Johnson (1992) presented the journey of an aerospace and defense contractor in building its strategic supplier partnerships through certain vision statements grounded on the concept of PS. Gassenheimer et al. (1995) worked on influencing the channel relationships between the suppliers and dealers, so as to bring governance and coordination. They highlighted the theoretical inconsistencies and raised a very relevant question on what is the minimum level in assigning preferred position to a supplier among the alternatives. Caddick and Dale (1998) conducted a resourceful study to examine various influences on purchasing through total quality management and have clearly explained the principle of PS concept. Larson and Kulchitsky (2000) studied the communication aspect in buyer-supplier relationships and they focused on the buyer's opinions regarding its closeness with a PS in the measurement. Cox (2001) addressed an important concern of buyers to leverage in making best deal with various types of suppliers (i.e. from arms-length to PSs). Halley and Nollet (2002) conducted an empirical study to examine the contributions of various types of suppliers to SC integration. They highlighted that preferred status should be given to right suppliers and for right reasons. The example of Starbucks is widely quoted by many researchers which focused on sustainability for business reasons. The company laid out four categories for evaluating the sustainability of its suppliers and accordingly awarded PSS (Chopra and Meindl, 2007). Sevkli et al. (2007) conducted a case study for supplier selection and in the background literature, they highlighted about Boeing and the basis of its successes through PS certification program. Delmas and Montiel (2009) investigated the suppliers' rationale indicating compliance or resistance to manufacturer's requirement to follow ISO 14001 environmental management standards. They mentioned about Ford using PSS in persuading its suppliers to follow environmental certification. Panayides and Venus Lun (2009) pointed the effects of trust on innovativeness and SC performance. They conceptualized that manufacturer's trust in the PS will have positive effect on firm's innovativeness and in turn on the SC performance. Rees (2011) interestingly uses the theory behind the bidirectional channel competition in the historical military as an analogy to present the examples of supply side competition. They emphasized a very important aspect that most of the companies are contended with defensive approach rather than having proactive supply management strategies. Erdem and Göçen (2012) developed a decision support model for supplier evaluation and order allocation. They have nicely reasoned the changing aspects of manufacturer's preference as well as disapproval to a supplier. In the light of literature review conducted, it was found that most of the studies mentioned above give sufficient theoretical insights and empirical conclusions related to PSS, but there is not enough research offered for a practicing manager to exercise the concept. Halley and Nollet (2002) also rightly pointed that those competitive advantages that a manufacturer is enjoying by the suppliers will eventually be possessed by every procurement department and hence, a manager has to proactively assess for achieving competitive supplier contributions.

Thus, a methodology has been proposed owing to the above discussed manufacturer-supplier orientations along the concept of PSS and to assist a manufacturer in measuring the PSS. For measuring the PSS, respective PSEs are identified and broadly grouped into three components namely Manufacturer's Interest Component (MIC), Common Interest Component (CIC) and Supplier Characteristic Component (SCC). The critical literature review of PSEs along with their contextual references highlighted along each PSE is shown in the Tables 4.2.1-4.2.3.

The types of supplier's relationships are expressed in various ways as per different conceptions and perspectives of various researchers. The suppliers are categorized into candidate preferred supplier, preferred supplier, best-in-class and approved (Johnson, 1992); vendor, preferred supplier, exclusive supplier and partner (Tang, 2007); approved supplier, preferred supplier and partnership (Gosling et al., 2015). In this study the type of supplier relationship dynamics with the manufacturer has been kept as preferred supplier alone, but the dynamics are quantified in terms of different levels of PSS along the timeline (i.e. past, present and future). Rationally, according to the nature of components under study, determination of PSS is based on MIC and CIC and SCC for determining the supplier characteristic score.

Table 4.2.1 Preferred supplier enablers under common interest component

Preferred supplier enabler	Contextual references highlighted about the PSE
Mutual visits by Competent Personnel (MCP)	Delmas and Montiel (2009); Hüttinger et al. (2012); Nollet et al. (2012); Ellegaard and Koch (2012)
Cost Savings and Value addition (CSV)	Christiansen and Maltz (2002); Winter and Lasch (2011); Schiele et al. (2011)
Trust (TRU)	Hald et al. (2009); Dahwa et al. (2013); Yeniyurt et al. (2014); Horn et al. (2014)
Top Management Commitment from both sides (TMC)	Delmas and Montiel (2009); Schiele (2010); Nollet et al. (2012); Schiele et al. (2011); Horn et al. (2014)
Buyer-Supplier Cooperation (BSC)	Forker and Stannack (2000); Caniëls et al. (2013); Leuschner et al. (2013)
Buyer-Supplier Coordination (BCO)	Winter and Lasch (2011); Mortensen (2012); Yan and Dooley (2014)
Buyer-Supplier Collaboration (BCL)	Park et al. (2010); Najafi Tavani et al. (2013)
Buyer-Supplier Compliance (BCP)	Nollet et al. (2012); Hüttinger et al. (2012); La Rocca et al. (2012); Yeniyurt et al. (2014)
Buyer-Supplier Communication (BCM)	Ellegaard et al. (2003); Ruben et al. (2007); Delmas and Montiel (2009); Hoffmann et al. (2013)
Certifications, Listings and Accreditations (CAC)	Delmas and Montiel (2009); Hüttinger et al. (2012); Lager and Storm (2012); Arroyo-López et al. (2012)
Buyer Supplier Compatibility (BSCt)	Cox (2004); Mwikali and Kavale (2012); Arroyo-López et al. (2012)
Improvement in Ethical and Moral business values (EMB)	Ramsay and Wagner (2009); Schiele et al. (2011); Ellis et al. (2012)

Table 4.2.2 Preferred supplier enabler under manufacturer interest component

Preferred supplier enabler	Contextual references highlighted about the PSE
Supplier Loyalty (SLY)	Ruben et al. (2007); Hüttinger et al. (2012); Mortensen and Arlbjørn (2012)
Supplier Commitment (SCT)	Caddick and Dale (1998); Handfield et al. (2006); Erdem and Göçen (2012); Baxter (2012)
Supplier Flexibility (SFL)	Erdem and Göçen (2012); Zhang et al. (2014)
Supplier Responsiveness (SRP)	Caddick and Dale (1998); Zhang et al. (2014)
Supplier Reliability (SRY)	Caddick and Dale (1998); Ruben et al. (2007)
Supplier's Environmental conscious Manufacturing (SEM)	Handfield et al. (2002); Delmas and Montiel (2009); Heikkurinen (2010)
Supplier Relationship Strength (SRS)	Wagner (2011); Friedl and Wagner (2012); Antony et al. (2012)
Supplier Pricing Structure (SPS)	Johnson (1992); Caddick and Dale (1998); Ruben et al. (2007)
Preferred Customer Perception (PCP)	Caddick and Dale (1998); Baxter (2012)
Supplier Responsibility (SRE)	Caddick and Dale (1998); Lavastre et al. (2012)
Supplier Integration Achieved (SIA)	Schiele (2012); van Blokland et al. (2013)
Supplier's Customer Satisfaction (SCS)	Wilson (1996); Baxter (2012); Zhang et al. (2014)
Supplier Performance Level (SPL)	Johnson (1992); Handfield et al. (2002); Tang (2007); Chen and Wu (2013); Zhang et al. (2014); Gosling et al., (2015)

Table 4.2.3 Preferred supplier enabler under supplier characteristic component

Preferred supplier's characteristic features	Contextual references highlighted about the PSE
Supplier Proximity (SPR)	Larson and Kulchitsky (2000); Halley and Nollet (2002); Sevkli et al. (2007)
Supplier's Supplier Condition (SSC)	Lee et al. (2009); Routroy and Sunil Kumar (2014)
Supplier's Business History (SBH)	Choy (2005); Erdem and Göçen (2012)
Supplier's Financial Capability (SFC)	Caddick and Dale (1998)(Caddick and Dale, 1998); Swinney and Netessine (2009);; Zhang et al. (2014)
Supplier's Resource Capability (SRC)	Johnson (1992); Caddick and Dale (1998); Sevkli et al. (2007); Erdem and Göçen (2012); Zhang et al. (2014)
Supplier Reputation and Brand name (SRB)	Sevkli et al. (2007); Heikkurinen (2010); Zhang et al. (2014)
Supplier's Information Infrastructure (SII)	Caddick and Dale (1998); Larson and Kulchitsky (2000); Halley and Nollet (2002)
Supplier Project Completion capability (SPC)	Gosling, Purvis, & Naim, (2010); Gosling et al. (2015)
Supplier's Innovation Capability (SIC)	Johnson (1992); Halley and Nollet (2002); Sevkli et al. (2007); Panayides and Venus Lun (2009); Erdem and Göçen (2012)
Supplier's Physical Distribution system (SPD)	Johnson (1992); Halley and Nollet (2002); Ruben et al. (2007)
Supplier's Facility Distribution (SFD)	Halley and Nollet (2002); Bates et al. (2012)
Supplier's Organizational Culture (SOC)	Handfield et al. (2006); Yang & Chen, (2006); Cannon et al. (2010)

4.2.3 Methodology

The proposed methodology is intended to determine the PSS of a manufacturer's key suppliers by analyzing the lists of PSEs under their respective Preferred Supplier Components (PSCs) (discussed in the previous section). It mainly uses extended FAHP to get preferred supplier scores and GRA to determine the supplier characteristic scores. The process flow of the said methodology shown in a flowchart (Figure 4.2.1) gives complete picture of the methodology and its step by step procedure is detailed below.

Step 1: Formation of Cross Functional Teams (CFTs)

Form the CFTs consisting of experts drawn from multiple departments of the manufacturer, who are closely connected with the suppliers, having adequate knowledge, skills and experience in the supplier management.

Step 2: Identification of relevant PSEs under respective components

Identify the list of PSEs under respective PSCs which can reflect the PSS of the suppliers from the manufacturer's point of view. These lists of PSEs can be obtained through literature review, brainstorming sessions and discussions held with the industry experts and CFTs. It must be ensured that right PSEs are chosen for the analysis by subjecting the lists of PSEs under various screening tests such as relevancy (whether or not, the chosen PSEs applicable in achieving PSS), accountancy (whether or not, all the requisite and sufficient PSEs are considered), redundancy (to eliminate any repeated PSEs), gross level significance (to safely eliminate any unimportant PSEs) and directional tests (to obtain uniformity in the direction of PSEs' effects).

Step 3: Determination of Fuzzy Synthetic Extent (FSE) for each PSE

Determine the FSE for each PSE's weight (under corresponding PSC) using FAHP method. Triangular Fuzzy Number (TFN) is used to express the FSE of a PSE '*i*' and it is denoted by W_i.

The following steps detail the procedure for calculating FSEs:

Step 3.1: Construction of pair wise comparison matrices of PSEs

Capture the relative importance between the PSEs using Pair Wise Comparison (PWC) matrices from each CFT. These PWCs should be carried out on a 1-9 scale (Saaty, 1990) (Table 4.2.4).

Table 4.2.4 Scale for pairwise comparisons (Source: Saaty, 1990)

Importance measure	Definition
1	Equally important
2	Equally to moderately more important
3	Moderately more important
4	Moderate to strongly more important
5	Strongly more important
6	Strong to very strongly more important
7	Very strongly more important
8	Very to extremely strongly more important
9	Extremely more important

Step 3.2: Check the consistency of pair wise comparison matrices

Carry out the consistency check to ensure that, the PWCs of the attributes (under corresponding PSC) are performed without any overriding of opinions. The consistency in the PWCs is measured in terms of consistency ratio. It is calculated as follows, normalize each column's values of the PWC matrices by dividing each entry with the sum of the column wise entries. Then, calculate the average of the entries across each row, this forms the principal vector (PV). If the PWC matrix is denoted by M_1, and the PV is denoted by M_2, then $M_3 = M_1 * M_2$ and $M_4 = M_3/M_2$. If λ_{max} is the average of the attributes of M_4, then the consistency index *(CI)* can be calculated by,

$CI = \frac{\lambda_{\max} - N}{N - 1}$, where '$N$' is the number of attributes under corresponding PSC. The Consistency Ratio *(CR)* is calculated by, $CR = \frac{CI}{RI}$, where *RI* is the random index corresponding to 'N' (Table 4.2.5). If the *CR* value is less than or equal to 10% (allowed percentage of error in the consistency), then the judgments can be considered consistent. If not, the CFTs have to improve their judgments in such a way that CR≤ 10%.

Table 4.2.5 Random Index values (Source: Thomas, 2000)

Number of attributes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Random Index	0	0	0.6	1	1.1	1.2	1.3	1.4	1.5	1.5	1.5	1.5	1.6	1.6	1.6

Step 3.3: Fuzzification of PWCMs of each CFT (Lee, 2009)

Fuzzify the individual PWC matrix obtained from each CFT by replacing the elemental values with the corresponding TFNs (as shown in the Table 4.2.6). The TFNs corresponding to the comparison of PSE 'i' with PSE 'j' by the CFT 'k' is denoted by $(P_{ijk}, Q_{ijk}, R_{ijk})$.

Table 4.2.6 Membership functions of the fuzzy numbers (Source: Lee, 2009)

Crisp judgment of the pairwise matrix	**Triangular Fuzzy Number**
1	(1,1,2)
2	(x-1, x, x+1) for x = 2,3,…,8
9	(8,9,9)
1/1	(2-1,1-1,1-1)
1/x	((x+1)-1,x-1,(x-1)-1) for x = 2,3,…,8
1/9	(9-1,9-1,8-1)

Step 3.4: Integration of fuzzified pair wise comparison matrices

Integrate the individual fuzzified PWC matrices by means of geometric mean method using the expressions shown below (Lee, Kang and Chang, 2009). The resultant integrated matrix constitute of elements in the form of triangular fuzzy numbers denoted by (a_{ij}, b_{ij}, c_{ij}).

$$a_{ij} = \left\{ \prod_{t=1}^{s} P_{ijk} \right\}^{1/s} \quad \forall i, j = 1, 2, \ldots, N$$

$$b_{ij} = \left\{ \prod_{t=1}^{s} Q_{ijk} \right\}^{1/s} \quad \forall i, j = 1, 2, \ldots, N$$

$$c_{ij} = \left\{ \prod_{t=1}^{s} R_{ijk} \right\}^{1/s} \quad \forall i, j = 1, 2, \ldots, N$$

Where, '*s*' denotes the number of CFTs participating in providing the judgments.

Step 3.5: Determination of FSEs of attributes under each PSC

Calculate the FSE for each PSE '*i*' denoted by W_i as shown below (Chang, 1996; A. H. I. Lee, 2009; and A. H. I. Lee, Kang, Hsu, & Hung, 2009):

$$W_i = \left(m_i^-, m_i, m_i^+ \right) = \left\{ \frac{\sum_{j=1}^{N} a_{ij}}{\sum_{i=1}^{N} \sum_{j=1}^{N} c_{ij}}, \frac{\sum_{j=1}^{N} b_{ij}}{\sum_{i=1}^{N} \sum_{j=1}^{N} b_{ij}}, \frac{\sum_{j=1}^{N} c_{ij}}{\sum_{i=1}^{N} \sum_{j=1}^{N} a_{ij}} \right\} \forall i = 1, 2, \ldots, N$$

Step 4: Calculating weights of PSCs

If the number of components for analysis are more than two then, the weights of components must be determined as discussed below. But, if the number is less than or equal to two then, the weights to the components can be assigned directly.

Calculate the FSEs of PSCs as per the procedure detailed from steps 3.1 to 3.5. These FSEs' are further compared against each other to ascribe a value called the Degree Of Possibility (DOPs) for each component. From the DOPs along each component, minimum value is to be selected and these minimum valued DOPs of each component are further normalized to obtain the weights of PSCs. The following equation is used in determining DOP $\mu(F_i)$,

$$\mu(F_2 \geq F_1) = \begin{cases} 1, & m_2 \geq m_1 \\ 0, & m_1^- \geq m_2^+ \\ \dfrac{[\, m_1^- - m_2^+]}{[(m_2 - m_2^+) - (m_1 - m_1^-)]} & otherwise \end{cases}$$

Step 5: Determination of average fuzzy performance rating for each PSE

Determine the Average Fuzzy Performance Ratings (AFPRs) for each PSE based on CFT's judgments along each timeline. The AFPR expressed in terms of TFN for PSE 'i' is denoted by 'R_i'. The procedure for finding the AFPRs of attributes is mentioned below:

Step 5.1: Collection of experts' judgments on performance rating of each PSE

Collect the Performance Ratings (PRs) of PSEs in terms of linguistic expressions along the past, present and target timelines from the CFTs. Replace these linguistic expressions by the corresponding TFNs shown in Table 4.2.7.

Table 4.2.7 Linguistic judgements for performance ratings (Source: Vinodh, Devadasan, Vimal, and Kumar, 2013)

Linguistic Expressions	Notation for expression	Corresponding TFN
Worst	W	(0,0.5,1.5)
Very Poor	VP	(1,2,3)
Poor	P	(2,3.5,5)
Fair	F	(3,5,7)
Good	G	(5,6.5,8)
Very Good	VG	(7,8,9)
Excellent	E	(8.5,9.5,10)

Step 5.2: Determination of average fuzzy performance rating

Determine the AFPR of each PSE (with respect to past, present and future timeline) by aggregating the multiple decision inputs using the arithmetic mean method. Calculate the AFPR denoted by R_i for a PSE 'i', by using the following equation.

$$\overline{R_{it}} = \frac{\sum_{k=1}^{s} R_{itk}}{s} \forall t = 1, 2, \ldots, n; \forall i = 1, 2, \ldots, N$$

Step 6: Calculation of FPM

Calculate the FPM along each timeline (past, present and target) by using the following equation:

$$FPM_{PSE} = \frac{\sum_{i=1}^{N} (W_i * \overline{R_{it}})}{\sum_{i=1}^{N} (W_i)} \forall t = 1, 2, \ldots, n; \forall PSC = \{MIC, CIC\}$$

Where, W_i is the FSE of a PSE 'i' obtained in the step 3.5.

Step 7: Determination of WFPM

Determine WFPMs using FPMs calculated in the previous step under respective PSCs (MIC and CIC) along the multi timeline. For ease in formulation and analysis, these components are assumed to be linear and independent. The following equation presents the same as discussed,

$$WFPM_t = \alpha \times FPM_t^{MIC} + (1 - \alpha) \times FPM_t^{CIC}$$

(Where, $WFPM$: Weighted Fuzzy Performance Measure, $t = 1,2,3 \ldots n$; $\alpha, and\ 1 - \alpha$ are the individual weights (step 4) assigned to the PSCs).

Step 8: Measuring Euclidean distances from predetermined preferential levels

The preferential levels are to be predefined in consultation with the CFT members along with their expressions in terms of TFNs (Table 4.2.8). It must be noted that, these expressed TFNs are largely environment specific and so, they cannot be generalized. Then, the Euclidean distance of WFPMs with reference to these predefined preferential levels are computed by using the equation shown below:

$$D\ (WFPM_t,\ PL_k) = \left\{ \sum_{x \varepsilon p} (f_{WFPM}(x)\ -\ f_{PL_k}(x))^2 \right\}^{1/2}$$

$$\forall t = 1,2,\ldots,n; \forall k = \{EP, VP, MP, FP, SP\}$$

Where $f_{WFPM}(x)$ represents the Weighted Fuzzy Performance Measure

$f_{PL_k}(x)$ represents the predefined Preferential Level $'k'$

Table 4.2.8 Predefined preferential levels with corresponding TFNs and percentages (Source: Vinoth et al., 2013)

Predefined Preferential Level (PL_k)	Notation for PL_k	Corresponding TFN ($f_{PL_k}(x)$)	Percentage
Extremely Preferred	EP	(7,8.5,10)	100 %
Very much Preferred	VP	(5.5,7,8.5)	80 %
Moderately Preferred	MP	(3.5,5,6.5)	60 %
Fairly Preferred	FP	(1.5,3,4.5)	40 %
Slightly Preferred	SP	(0,1.5,3)	20 %

Step 9: Determination of PSS

The minimum among the Euclidean distances (measured from the predefined preferential levels) represents the corresponding PSS of a supplier with respect to the PSC and the timeline, it is further converted in to percentage score (Table 4.2.8). These percentage scores convey the preferential status ascribed to the supplier by the manufacturer under each component and along the different timeline.

Step 10: Determination of preferential supplier score

To obtain the preferential supplier scores of the suppliers defuzzify their WFPMs (obtained in the step 7) and calculate the crisp scores (supplier's preferential scores) by using the equation of defuzzification (Kwong and Bai, 2003). It is given by: $CS_{ij} = (l_{ij} + 4m_{ij} + n_{ij})/6$; where, CS_{ij}: Crisp score ; l_{ij}: left spread of the performance measure; m_{ij}: mean value of the performance measure; n_{ij}: Right spread of the performance measure. Although in the current methodology the Weighted Mean Method is proposed for defuzzification, users are cautioned to check consistency ratios of PWCMs carefully and adopt better defuzzification methods for arriving at reliable results (Başaran, 2012).

Step 11: Determination of Supplier Characteristic Score Using Grey Relational Analysis

Grey Relational Analysis (GRA) is a simple, straight forward and one of the best methods to make decisions in the business environment (Wu, 2002). It was proposed by Ju-Long (1982) to solve the uncertain problems with insufficient data and various types of data. In order to conduct the GRA for determining the supplier characteristic score, the PSEs under SCC are to be used and the weights of these PSEs are to be obtained by following the steps 3 and 4. The weights of PSEs indicate the significance of each PSE (under SCC) for the manufacturer and thereby if any insignificant weights are obtained, those corresponding PSEs must be eliminated before conducting the GRA. Once if the significant PSEs are considered, the step by step procedure of GRA can be applied as detailed below (Wu, 2002):

Step 11.1: *Generate the referential series*

Develop a compared series matrix X_i with the key supplier values along the PSEs under SCC. The supplier data values in X_i can be quantitative or qualitative or both. Here, if the quantitative values of the suppliers are directly available then they can be used as it is. However, if the measures include any qualitative factors then the qualitative ratings (as per Table 4.2.7) can be taken from the CFTs. Extract the best supplier values for the manufacturer as a referential series denoted by x_o.

Step 11.2: *Normalization of supplier data values*

Normalize the supplier data values in the compared series matrix X_i as well as those in the reference series x_o by treating with one of the three types namely, larger-is-better/ smaller-is-better/ nominal-is-best equation of transformation. After normalization, X_i is represented as X_i^* and x_o is represented as x_o^*. Here 'i' refers to the row index of the compared series matrix and 'j' refers to the entry index of the reference series.

Equation for the larger-is-better is,

$$x_i^*(j) = \frac{x_i(j) - \min_j x_i(j)}{\max_j x_i(j) - \min_j x_i(j)}$$

Equation for the smaller-is-better is,

$$x_i^*(j) = \frac{\max_j x_i(j) - x_i(j)}{\max_j x_i(j) - \min_j x_i(j)}$$

Where, $\min_j x_i(j)$ represents the minimum value and $\max_j x_i(j)$ represents the maximum value among the data values of x_i with reference to the value of entry 'j'.

Equation for the nominal-is-best is,

$$x_i^*(j) = \frac{|x_i(j) - x_t(j)|}{\max_j x_i(j) - x_t(j)}$$

Where, the target value here is set to $x_t(j)$ such that, $\min_j x_i(j) \le x_t(j) \le \max_j x_i(j)$

Step 11.3: Calculation of absolute difference matrix

Calculate the absolute distance with reference to the value of entry 'j' to obtain the absolute difference matrix by using the following equation,

$$\Delta_{oi}(j) = |x_o^*(j) - x_i^*(j)|$$

Step 11.4: Calculation of grey relation coefficient matrix

Calculate the grey relation coefficient by using the following equation,

$$\gamma_{oi} = \frac{\Delta \min + \zeta \Delta \max}{\Delta_{oi}(j) + \zeta \Delta \max}$$

Where, $\Delta \min = \min_{i} \min_{j} \Delta_{oi}(j)$, $\Delta \max = \max_{i} \max_{j} \Delta_{oi}(j)$. ζ is a distinguishing coefficient which takes values [0,1].

Step 11.5: Calculation of grey relational grade

Calculate the grey relational grade by using the following equation,

$$\Gamma_{oi} = \sum_{j=1}^{n} [We_i(j) \times \gamma_{oi}(j)]$$

Where, $We_i(j)$ represents the weights of PSEs under PCC obtained by following the steps 3 and 4 in previous section. If the grey relational grade of a supplier is higher it means it is a featured supplier for the manufacturer.

Step 11: Supplier's characteristic and preferential status plot

Plot the distribution of the suppliers by the ordering the pairs as Supplier (along X-axis), supplier characteristic scores (along Y-axis) and supplier's preferential scores (along Z-axis). This plot would help a manufacturer to choose PSs as well as featured suppliers.

The whole methodology is coded into a simple application program using MATLAB R2013b. The following section deals with the application of the above proposed methodology to an Indian automotive component manufacturing company in order to demonstrate and explain its salient features.

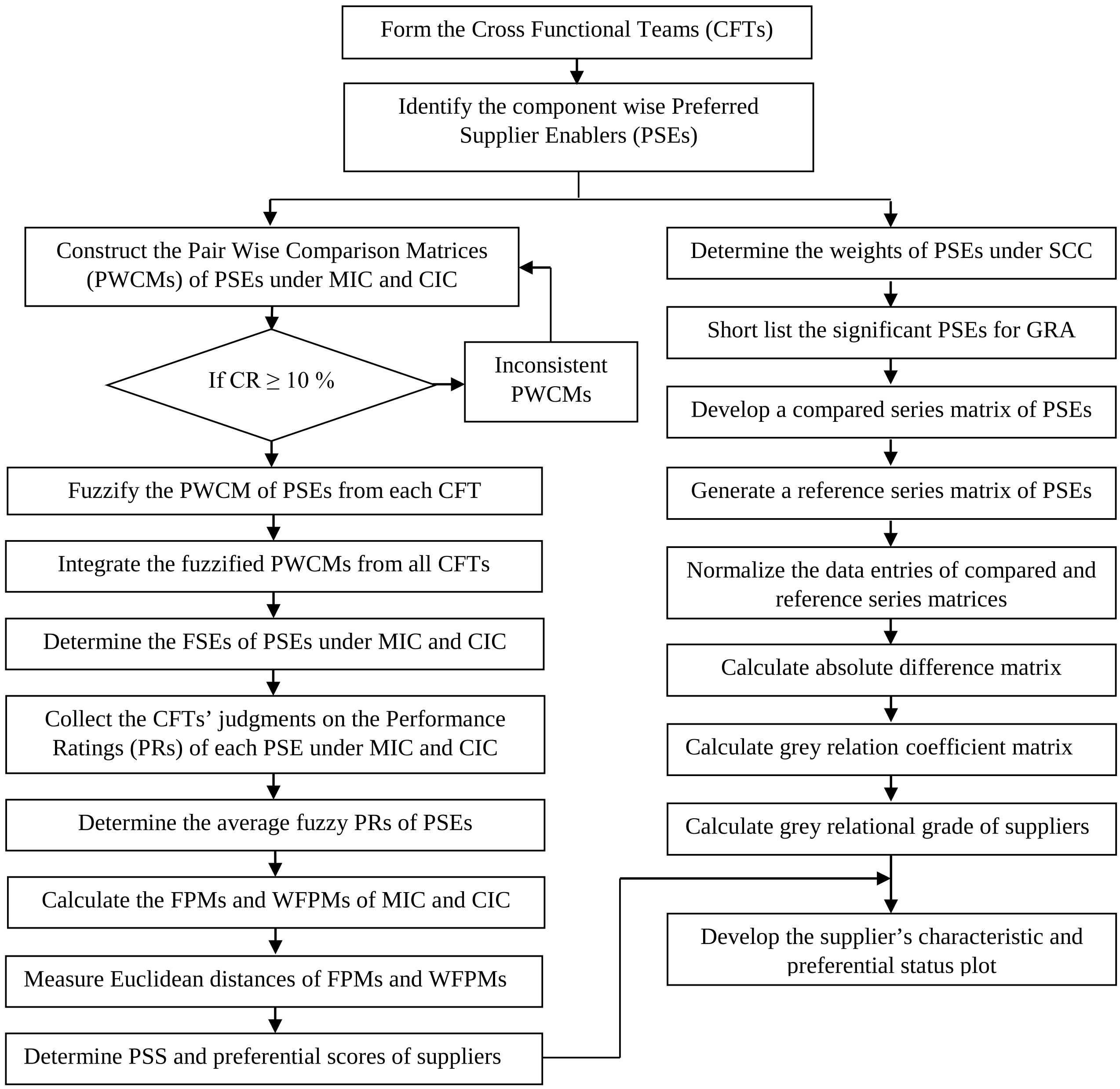


Figure 4.2.1 Methodology to measure preferred supplier status

4.2.4 Application of proposed methodology

The proposed methodology detailed in the previous section was implemented in an automotive component manufacturing company located in the western part of India and its application is discussed in this section to demonstrate its utility. Following the non-disclosure agreement made with the company, its name is not disclosed in the current discussion and from now on it is referred as company ‘Q’. Its primary business is to manufacture standardized as well as customized automotive components (related to the transmission systems) for the OEM manufacturers. It is a large scale manufacturing company with a gross turnover more than ₹80 billion. It is mainly known for its brand, quality, reliability and product availability. It has many key suppliers supplying critical parts to the components it is producing. One of the best practice in the company is, it values the opinions of its suppliers and pays back to the contributions made. It has a strong research and development team working closely with the suppliers mainly focusing on quality improvement and new product development. It was with this team the authors’ research project is partnered and the proposed methodology is a part of the research being conducted. The manufacturer’s response when asked for their experience with the suppliers was, the system is mostly reactive and defensive i.e. as long as there is no huge loss, everything is fine with the suppliers. However, they expressed that they are building certain systems to develop the suppliers over a period so as to take them along with its growth and thereby help the suppliers to contribute, improve and make profits. When asked whether they measure and award preferential status to their suppliers, the response was, preferences are given mostly on the basis of feedback meetings, but they do not practice measuring PSS of its suppliers. Then, when the objectives of the proposed methodology were explained, there was positive interest in conducting the study and they promptly accepted to share their opinions as inputs. As discussed in the methodology, eighteen experts from various departments were invited and they were divided into three CFTs (named as A, B and C in the current discussion). All the CFTs were balanced to have proper blend of knowledge, skills, designation and with minimum experience of 7 years. Thereafter, the identified PSEs were shared with the CFTs and through their opinions the PSEs were subjected to various screening tests (step 2 of methodology). Then as per step 3, FAHP was applied on the relevant PSEs to determine the respective FSEs of PSEs.

According to step 3.1 of methodology, PWCMs of PSEs under respective components were formed and CFTs were asked to fill the PWCMs. The consistency of PWCMs were checked according to step 3.2 (Table 4.2.9 shows the PWCM obtained from CFT A under MIC) and then they were fuzzified and integrated as per steps 3.3 and 3.4 (Table 4.2.10 shows the fuzzified and integrated PWCM obtained from the CFTs under MIC). Then according to step 3.5, on the basis of fuzzified and integrated PWCMs, the FSEs were determined (Table 4.2.11). At this juncture, according to step 4, the weights of PSCs can be determined however, since there were only two PSCs in the current study excluding SCC, equal weights were assigned to both MIC and CIC. Then according to step 5, to determine the AFPRs of PSEs, CFTs were asked to express the performance ratings of its key suppliers. Five key suppliers' performance ratings were collected and PSSs were determined (i.e. S_1, S_2, S_3, S_4 and S_5), but for ease in presentation detailed results of only one supplier (i.e. S_1) are discussed in this section. After obtaining the PRs of each PSE, the AFPRs of PSEs were determined according to step 5.2. Thereafter, the FPMs of both MIC and CIC were determined along the three timelines i.e. past (last year), present (this year) and target (next year) (step 6) on the basis of obtained AFPRs. Then as per step 7, WFPMs of PSEs along each timeline were determined. Using the obtained FPMs and WFPMs along the respective timeline, the Euclidean distances were determined from the predefined PS performance levels (step 8 and Table 4.2.12). According to step 9, the PSS of the key suppliers were determined and their corresponding preferential scores were obtained as per step 10 (Table 4.2.13 and Figure 4.2.2). Next, as per step 11, the weights of PSEs under SCC were determined and 10 out of 12 PSEs were considered to determine the supplier characteristic scores by applying GRA. According to step 11.1, the comparison series matrix of five suppliers along the 10 PSEs was formed (which consists of qualitative and quantitative values) and from that a reference series matrix was formed (by extracting best of the values). As per step 11.2, the entries in the comparison series and reference series matrices were normalized according to the nature of PSE desired by the manufacturer i.e. whether larger-is-better/ smaller-is-better/ nominal best. Then the absolute distance between the entries along each row in the comparison series matrix from the entries in the reference series matrix were calculated to obtain absolute difference matrix (step 11.3). Then as per step 11.4, on the basis of absolute difference matrix, the grey relation coefficient matrix was developed. According to step 11.5, the weights of PSEs and the entries along each row of the grey relation coefficient matrix were multiplied to obtain the grey relational grades/ supplier characteristic scores of the five suppliers. To know the stability in GRA output, the data were processed by varying the distinguishing coefficient from 0.1 to 1 (Figure 4.2.3). Finally as per step 12, the suppliers' characteristic and preferential status plot was made by plotting the suppliers on X-axis, supplier characteristic score on Y-axis and PS score on Z-axis (Figure 4.2.4). The obtained results after applying the proposed methodology and their interpretation are discussed in detail in the next section. Although, the above mentioned operational steps sound cumbersome, the application program developed in MATLAB R2013b executes everything and reduces the computational burden on the user.

Table 4.2.9 The pair wise comparison matrix obtained from CFT A under MIC

PSE	SLY	SCT	SFL	SRP	SRY	SEM	SRL	SPS	PCP	SRE	SIA	SCS	SPL
SLY	1	1	0.5	2	0.5	3	3	0.5	2	4	3	4	0.5
SCT	1	1	0.5	2	0.5	3	3	0.5	2	4	3	4	0.5
SFL	2	2	1	3	1	4	4	1	3	5	4	5	1
SRP	0.5	0.5	0.333	1	0.333	2	2	0.333	0.333	3	2	3	0.333
SRY	2	2	1	3	1	4	4	1	3	5	4	5	1
SEM	0.333	0.333	0.25	0.5	0.25	1	1	0.25	0.25	2	1	2	0.25
SRL	0.333	0.333	0.25	0.5	0.25	1	1	0.25	0.25	2	1	2	0.25
SPS	2	2	1	3	1	4	4	1	3	5	4	5	1
PCP	0.5	0.5	0.333	3	0.333	4	4	0.333	1	3	2	3	0.333
SRE	0.25	0.25	0.2	0.333	0.2	0.5	0.5	0.2	0.333	1	0.5	1	0.2
SIA	0.333	0.333	0.25	0.5	0.25	1	1	0.25	0.5	2	1	2	0.25
SCS	0.25	0.25	0.2	0.333	0.2	0.5	0.5	0.2	0.333	1	0.5	1	0.2
SPL	2	2	1	3	1	4	4	1	3	5	4	5	1
λ_{max} = 13.349, CI=0.029, RI[13] = 1.56, CR=0.0186, Since CR <= 0.1. It is CONSISTENT													

Table 4.2.10 The fuzzified and integrated PWCM of PSEs obtained from the CFTs under MIC

PSE	SLY	SCT	SFL	SRP	SRY	SEM	SRL	SPS	PCP	SRE	SIA	SCS	SPL
SLY	(1,1,1)	(1,1,2)	(0.48,0.63,1.26)	(1,2,3)	(0.48,0.63,1.26)	(2,3,4)	(1.59,2.62,3.63)	(0.48,0.63,1.26)	(1,2,3)	(3,4,5)	(1.59,2.62,3.63)	(3,4,5)	(0.48,0.63,1.26)
SCT	(0.5,1,1)	(1,1,1)	(0.48,0.63,1.26)	(1,2,3)	(0.48,0.63,1.26)	(2,3,4)	(1.59,2.62,3.63)	(0.48,0.63,1.26)	(1,2,3)	(3,4,5)	(1.59,2.62,3.63)	(3,4,5)	(0.48,0.63,1.26)
SFL	(0.79,1.59,2.08)	(0.79,1.59,2.08)	(1,1,1)	(1.59,2.62,3.63)	(1,1,2)	(2.62,3.63,4.64)	(2.29,3.30,4.31)	(1,1,2)	(1.59,2.62,3.63)	(3.63,4.64,5.65)	(2.29,3.30,4.31)	(3.63,4.64,5.65)	(1,1,2)
SRP	(0.33,0.5,1)	(0.33,0.5,1)	(0.28,0.38,0.63)	(1,1,1)	(0.28,0.38,0.63)	(1,2,3)	(1,1.59,2.62)	(0.28,0.38,0.63)	(0,2.18,0)	(2,3,4)	(1,1.59,2.62)	(2,3,4)	(0.28,0.38,0.63)
SRY	(0.79,1.59,2.08)	(0.79,1.59,2.08)	(0.5,1,1)	(1.59,2.62,3.63)	(1,1,1)	(2.62,3.63,4.64)	(2.29,3.30,4.31)	(1,1,2)	(1.59,2.62,3.63)	(3.63,4.64,5.65)	(2.29,3.30,4.31)	(3.63,4.64,5.65)	(1,1,2)
SEM	(0.25,0.33,0.5)	(0.25,0.33,0.5)	(0.22,0.28,0.38)	(0.33,0.5,1)	(0.22,0.28,0.38)	(1,1,1)	(0.69,0.79,1.59)	(0.22,0.28,0.38)	(0.28,0.40,0.69)	(1,2,3)	(0.69,0.79,1.59)	(1,2,3)	(0,0,0)
SRL	(0.28,0.38,0.63)	(0.28,0.38,0.63)	(0.23,0.30,0.44)	(0.38,0.63,1)	(0.23,0.30,0.44)	(0.63,1.26,1.44)	(1,1,1)	(0.23,0.30,0.44)	(0.41,0.5,0.87)	(1.26,2.29,3.30)	(1,1,2)	(1.26,2.29,3.30)	(0.23,0.30,0.44)
SPS	(0.79,1.59,2.08)	(0.79,1.59,2.08)	(0.5,1,1)	(1.59,2.62,3.63)	(0.5,1,1)	(2.62,3.63,4.64)	(2.29,3.30,4.31)	(1,1,1)	(1.59,2.62,3.63)	(3.63,4.64,5.65)	(2.29,3.30,4.31)	(3.63,4.64,5.65)	(1,1,2)
PCP	(0.33,0.5,1)	(0.33,0.5,1)	(0.28,0.38,0.63)	(0,0.459,0)	(0.28,0.38,0.63)	(1.44,2.52,3.56)	(1.145,2,2.47)	(0.28,0.38,0.63)	(1,1,1)	(2,3,4)	(1,1.59,2.62)	(2,3,4)	(0.28,0.38,0.63)
SRE	(0.2,0.25,0.33)	(0.2,0.25,0.33)	(0.18,0.22,0.28)	(0.25,0.33,0.5)	(0.18,0.22,0.28)	(0.33,0.5,1)	(0.30,0.44,0.79)	(0.18,0.22,0.28)	(0.25,0.33,0.5)	(1,1,1)	(0.30,0.44,0.79)	(1,1,2)	(0.18,0.22,0.28)
SIA	(0.28,0.38,0.63)	(0.28,0.38,0.63)	(0.23,0.30,0.44)	(0.38,0.63,1)	(0.23,0.30,0.44)	(0.63,1.26,1.44)	(0.5,1,1)	(0.23,0.30,0.44)	(0.38,0.63,1)	(1.26,2.29,3.30)	(1,1,1)	(1.26,2.29,3.30)	(0.23,0.30,0.44)
SCS	(0.2,0.25,0.33)	(0.2,0.25,0.33)	(0.18,0.22,0.28)	(0.25,0.33,0.5)	(0.18,0.22,0.28)	(0.33,0.5,1)	(0.30,0.44,0.79)	(0.18,0.22,0.28)	(0.25,0.33,0.5)	(0.5,1,1)	(0.30,0.44,0.79)	(1,1,1)	(0.18,0.22,0.28)
SPL	(0.79,1.59,2.08)	(0.79,1.59,2.08)	(0.5,1,1)	(1.59,2.62,3.63)	(0.5,1,1)	(0,0,0)	(2.29,3.30,4.31)	(0.5,1,1)	(1.59,2.62,3.63)	(3.63,4.64,5.65)	(2.29,3.30,4.31)	(3.63,4.64,5.65)	(1,1,1)

Table 4.2.11 Fuzzy synthetic extents of PSEs

PSEs under MIC	m_i^-	m_i	m_i^+	PSEs under CIC	m_i^-	m_i	m_i^+
SLY	0.051	0.1	0.207	MCP	0.043	0.084	0.188
SCT	0.049	0.1	0.202	CSV	0.067	0.134	0.275
SFL	0.069	0.129	0.253	TRU	0.065	0.134	0.268
SRP	0.029	0.068	0.128	TMC	0.063	0.134	0.26
SRY	0.068	0.129	0.247	BSC	0.049	0.098	0.203
SEM	0.018	0.036	0.082	BCO	0.043	0.087	0.181
SRL	0.022	0.044	0.094	BCL	0.046	0.098	0.19
SPS	0.066	0.129	0.241	BCM	0.023	0.048	0.111
PCP	0.031	0.065	0.13	BCP	0.04	0.087	0.17
SRE	0.014	0.022	0.049	BSCt	0.021	0.048	0.103
SIA	0.021	0.045	0.088	CAC	0.016	0.027	0.061
SCS	0.012	0.022	0.043	EMB	0.012	0.022	0.042
SPL	0.057	0.114	0.208				

Table 4.2.12 Euclidean distance measures of Fuzzy Performance Measures

Supplier preference Level	FPM_{MIC}			FPM_{CIC}			WFPM			Percentage Preferred
	Past	Present	Target	Past	Present	Target	Past	Present	Target	
EP	8.75	3.78	2.02	7.89	5.34	2.84	8.32	4.56	2.43	100%
VP	6.16	1.18	0.70	5.30	2.77	0.29	5.73	1.97	0.32	80%
MP	2.71	2.29	4.09	1.87	0.88	3.24	2.28	1.54	3.66	60%
FP	0.88	5.75	7.54	1.70	4.23	6.70	1.28	4.98	7.12	40%
SP	3.41	8.35	10.14	4.27	6.82	9.29	3.84	7.58	9.72	20%

Table 4.2.13 Suppliers' preferential and characteristic scores

Supplier	Supplier Preferential Score			Supplier Characteristic Score
	Past	Present	Target	
S_1	3.5666	5.8681	7.1139	0.5153
S_2	3.1621	5.4634	5.8685	0.3853
S_3	4.2374	6.0661	6.7280	0.3996
S_4	5.2942	7.1586	7.7874	0.5534
S_5	5.9300	7.5679	8.6639	0.9508

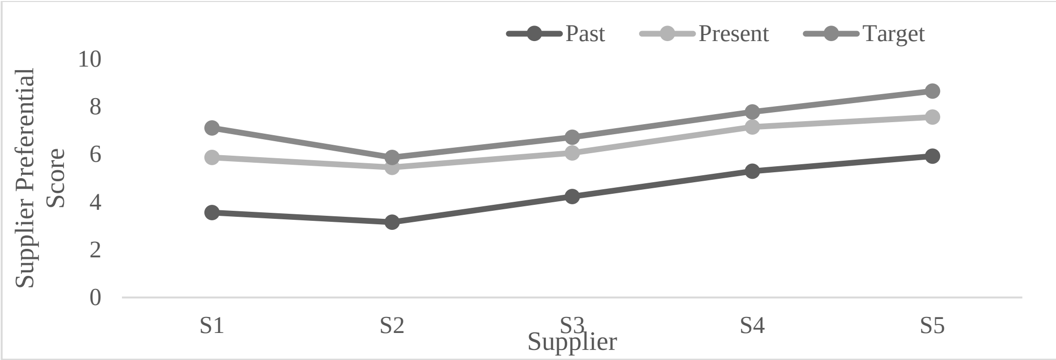


Figure 4.2.2 Suppliers' preferential score plot along the timeline

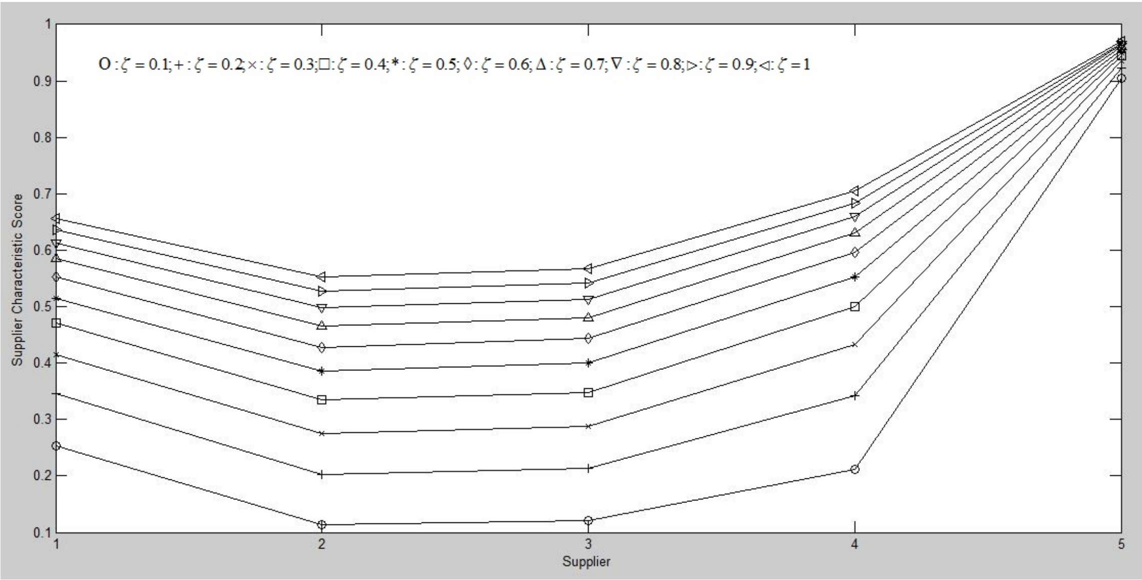


Figure 4.2.3 Suppliers' characteristic score for different distinguishing coefficient values

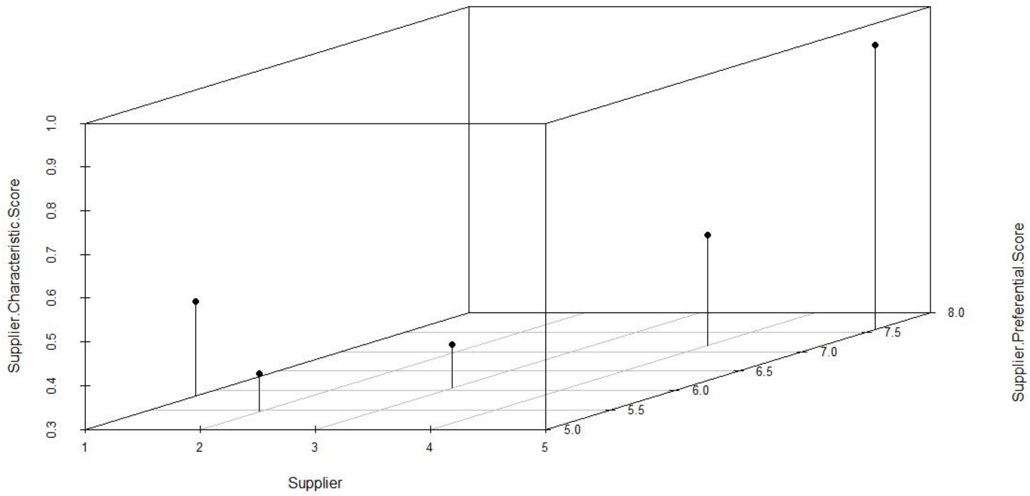


Figure 4.2.4 Suppliers' characteristic and preferential status plot along present timeframe

4.2.5 Results and discussions

The lowest Euclidean distances obtained from FPM_{MIC} to different predefined preferential levels were, 0.88 (FP) in the past, 1.18 (VP) at present, 0.70 (VP) as target (Table 4.2.12). By these it can be inferred that, PSS of S_1 was improved from fairly preferred in the past to very much preferred at present and it is targeted to become more improved along the very much preferred level. In other words, the course of action for S_1 is to reduce its performance gap of FPM_{MIC} from 1.18 to 0.70 along the very much preferred level. Similarly, the lowest Euclidean distances obtained from FPM_{CIC} to different predefined preferential levels were, 1.70 (FP) in the past, 0.88 (MP) at present, 0.29 (MP) as target from different predefined preferential levels (Table 4.2.12). It can be inferred that, PSS of S_1 was improved from fairly preferred in the past to moderately preferred at present and it is targeted to follow the trend to become very much preferred. It can be observed that, from present state to targeted state, S_1 has to marginally reduce its performance gap from 0.88 at moderately preferred level to 0.29 towards the fullest extent of very much preferred level. Finally, the lowest Euclidean distances obtained from WFPM to different predefined preferential levels were, 0.32 (FP) in the past, 1.54 (MP) at present and 1.28 (VP) as target. It can be inferred that, S_1's status has been improved from fairly preferred in the past to moderately preferred at present and it is targeted to become very much preferred. It can be observed that, on the whole S_1 is following the improvement trend in achieving PSS. In terms of percentage score, S_1 has acquired 60% of PSS at present and it is expected to become 80% preferred. The PSSs of all the five key suppliers were determined and their absolute preferential scores along the timeline are shown in Table 4.2.13 and Figure 4.2.2. On the basis of preferential scores of the suppliers (along the present timeline) it was found that $S_5>S_4>S_3>S_2>S_1$ i.e. S_5 is the most PS for the case company.

The weights of PSEs under SCC were determined in order to choose the significant PSEs and obtain the characteristic scores of the suppliers. It was found that, out of 12 PSEs, SFD and SOC were insignificant supplier characteristic features for the case company and hence, they were eliminated in determining the suppliers' characteristic scores. The obtained scores (Table 4.2.13) point out that, $S_5>S_4>S_1>S_3>S_2$ i.e. S_5 and S_4 are the most characteristically featured suppliers for the case company. In order to check the degree of stability in the obtained order of suppliers, a plot of suppliers' characteristic scores for different values of distinguishing coefficient from 0.1 to 1 was developed. It showed up stable trends in the suppliers' sequence and primarily supported the obtained order of suppliers at $\zeta = 0.5$ (Figure 4.2.3). Finally, the developed suppliers' characteristic and preferential status plot (Figure 4.2.4) at once gives the glimpse of distribution of suppliers in meeting characteristic features and preferential status of the case company. It can be seen from the plot that, S_5 is the most dominating supplier compared to others. Hence, the company 'Q' can show S_5 as a benchmark supplier to others and invest preferentially in dealing with S_5 considering its long term relationship benefits. Further, although S_4 is competent enough in achieving preferential status, it is relatively lagging behind in terms of characteristic features and S_1 though it is as good as S_4 in terms of characteristic features, yet it is lagging in PSS compared to S_4. Moreover, from the plot it can be seen that except S_5 all other suppliers are not characteristically significant, which questions the process of supplier selection by the case company. When it comes to achieving PSS, apart from S_5 and S_4 all others are seriously lagging. Thus, based on the obtained results, the manufacturer is recommended to preferentially work with S_5 and S_4 and also take necessary actions for reducing the performance gaps among the suppliers. Also, the company was suggested, to measure PSSs of the suppliers' time to time and maintain the data to have proper record of relationship dynamics, to know the reliability and other captured details of the suppliers. The R&D personnel of the company shared that, they have 200 suppliers working under various projects and out of them around 80 suppliers are key to them.

They said they would circulate the application program to the managers and gradually incorporate and improvise the practice of measuring PSS.

4.2.6 Sectional summary

Measuring PSS would enable a manufacturer to ascribe preferences to the right suppliers as supply base contribution has become one of the essential components for a manufacturer to compete with other SCs. It is with this purpose; an approach has been proposed for a manufacturer's assistance to measure the PSS of its suppliers. The approach mainly uses FAHP, Euclidean distance measure and GRA method in measuring the PSS of the suppliers. In measuring PSS, the PSEs obtained from literature review and grouped under MIC, CIC and SCC were used. In order to demonstrate the utility of the approach, a case study conducted in an Indian automotive component manufacturing company by considering its five key suppliers has been presented. Using the PSEs under MIC and CIC, the overall preferential scores of the suppliers were determined along the timeline. For ease in presentation, mainly the results obtained related to only one supplier (i.e. S_1) were discussed. It was observed that although the preferential status of the supplier has been following the improvement trend, it was still falling behind in comparison to the other suppliers. To get more comprehensive view about all the suppliers, the characteristic scores of the suppliers were also determined using the PSEs under SCC by applying GRA. Based on the preferred supplier scores and the supplier characteristic scores, a supplier's characteristic and preferential status plot was developed. From the plot, it was observed that the suppliers S_5 and S_4 were relatively more preferred and S_5 alone is a featured supplier for the case company. Hence, it was recommended that the manufacturer has to give priority to S_5 and S_4 in proposing its initiatives. However, it was suggested that the manufacturer has to appeal the improvement strategies for other suppliers to achieve PSS.

Chapter 5

Framework for Supplier Development Furtherance

5 Sectional abstract

The purpose of this section is to develop and analyze a Supplier Development (SD) furtherance model for systematic SD execution and extension into the manufacturing supply chain backward linkages in India. In this regard, an empirical study was conducted in the Indian manufacturing environment and factor analysis was conducted to extract the principal components and to establish a measurement model. Then, path analysis was performed to build an SD furtherance model in conformance to the measurement model. Finally, on the basis of SD furtherance model, a Bayesian network was structured to analyze the combined effects of the structural variables. It was found that, when a Supplier's Conduct and Status (SCST) is at lower level then it does not offer much improvement in the Buyer-Supplier Understanding (BSUD) and there would be increasing effect on BSUD at medium level of SCST, but higher level of SCST leads to devolving effect on BSUD. It was also found that, from lower to medium levels of BSUD there would be increasing effect on SD Practice and Reach (SDPR) whereas higher levels of BSUD it was noticed that SDPR would have a falling effect. To mention the research implications: the probable levels of combined effects accounted in the current study could have incorporated the degree of impact and quantified the states of the variables. With regards to applicability, the obtained results would be more relevant in the Indian context. To highlight the practical implications: the SD furtherance model and its diagnosis assist the manufacturers to have a proper SD system laid out and progressively extend it into the backward linkages of the supply chains. To mention about the originality of the work: the logical conclusions arrived through the SD furtherance model and its diagnosis can be used in the systematic SD execution and extension.

5.1 Necessity for SD furtherance framework

Due to the ever increasing immense competition between the supply chains, the manufacturers are proactively exploring for sustainable competitive advantages. Consequently, most of the manufacturers started increasing their dependency on the selected suppliers to acquire competitive supplies and also intensify their focus on core competencies (Khan and Pillania, 2008). Manufacturers also find depending on specialized suppliers to be effective when the in-house production alternative does not afford sufficient economies of scale, adequate knowledge and learning in the processes. Besides, the supplier dependency has become so strong-growing among the manufacturers that often when the suppliers are not at par in meeting the requirements, then SDPs are proposed for evolving and strengthening the suppliers' capabilities. Also, the manufacturers many at times choose SDPs to cultivate their chosen suppliers when they do not have feasible suppliers to meet their long term requirements.

The term "Supplier development" was first used by Leenders (1966) while mentioning about a manufacturer's efforts for improving its suppliers' performance (Krause et al., 2007). Krause (1997) defines Supplier Development (SD) as "any effort of a firm to increase performance and/or capabilities to meet the firm's short- and/or long-term supply needs". After making thorough assimilation of various views of the researchers in defining the term "Supplier Development", it is broadly redefined as,

"A manufacturer's strategic and competitive program aimed at winning a selected supplier's confidence to mutually invest, innovate, and integrate for achieving desired transformations along the supplier's (in specific) and the supply chain backward linkage's (in general) exclusive domains matched with the selected customers' requirements".

The SD has been proven to be one of the effective ways a manufacturer can achieve improved supplier's performance in terms of product quality, on time deliveries, huge cost reduction opportunities (product, inventory and transaction costs), reliable and flexible supply base, enhanced supplier's financial capability, develop competitive features that are hard to replicate, avoid the control of unfair suppliers, rationalize the supply base size and there by avoid the multiplied complexities, achieve the dedicated relationship specific resources from the suppliers, improved assistance in the new product development and improved success through the relationship based business (Carr and Kaynak, 2007; Modi and Mabert, 2007; and Matook et al., 2009). Owing to these benefits an SD can offer, it can be attributed as a successful mode for the manufacturers to pursue with their selected suppliers. However, with regards to the situation, the responsibility lies on the focal manufacturing firms in executing and extending the SD into the backward linkages of the supply chains to achieve overall supply chain development.

In executing and extending an SD along a supply chain, most of the manufacturers have their backward linkages rooted in the developing countries like India (primarily to achieve the cost benefits). To highlight more about the scenario of India and its manufacturing suppliers, besides being the low cost sourcing destination India is rapidly emerging as an attractive global sourcing hub. Indian manufacturing suppliers are capable of offering a wide variety of competitive advantages that satisfy the total cost perspective of the manufacturers (according to India Brand Equity Foundation (IBEF) report entitled "India ranked as the top investment destination – EY's 2015 India attractiveness survey" accessed on December 3rd, 2015). Even Mckinsey (knowledge partner for Automotive Component Manufacturers Association of India) has reported that the Indian suppliers are well positioned with the global trends specifically in the auto industry (Mehta, 2014). With effective de-risking strategies like enabling the suppliers' to diversify their core competencies across the other industries are making Indian suppliers to be less affected with the cyclical fluctuations and become financially stronger (Mehta, 2014). Partnering with these type of suppliers, the global manufacturers can have SD as a potential mode to transform the suppliers as feasible and susceptible to their customers' requirements. Having said about a manufacturer's inclination towards suppliers and SD, SD's influence to bring about tremendous favorable moments in the suppliers' transformations and Indian manufacturing environment, the current study is focused in developing a SD furtherance model. On the basis of this model the manufacturers can effectively conduct SD and extend it along the backward linkages of the supply chains in the Indian manufacturing environment.

This section is subdivided as follows: Section 5.2 presents the literature review; Section 5.3 details the research methodology followed in carrying out the study; Section 5.4 features the questionnaire design, data collection and analysis; Section 5.5 contains the results and discussions; and Section 5.6 highlights the conclusions drawn from the interpretation of the results.

5.2 Literature review in support of SD furtherance framework

In this section, the literature review has been presented along the two aspects, (1) Instituting the need for a framework to execute SD and extend it into the backward linkages of the supply chains and (2) Exploring the excerpts from previous research works that specifically highlighted the factors governing SD practice and its progress.

Traditionally with reference to the past procurement procedures, most of the suppliers are not properly integrated into the manufacturing supply chains. This was clearly mentioned by Lascelles and Dale, (1989) in their study on the barriers that were hindering the development of manufacturer-supplier relationships. Manufacturers were indifferent in the relationships with the suppliers and used to be functional, transactional and even many at times, the suppliers' role was not considered in the value addition process (Trent, 2007). But, the extraneous influences (such as globalization, increased scarcity of resources, technological advancements, compressed product life cycles, increasing customer awareness and demands, unstable economies and political scenarios, and even the manufacturers' choice to become less vertically integrated) have eventually forced the manufacturers to transcend the transactional relationships and become more selective in the supplier relationships (Watts and Hahn, 1993, Herbig and O'Hara, 1996, and Routroy and Sunil Kumar, 2014). Unlike the traditional ways, the manufacturers must carefully associate with the highly qualified suppliers and accordingly uphold the relationship at a strategic level rather than being merely transactional (Salam, 2011). In order to elevate the transactional relationships to a strategic level, the manufacturers have to incorporate the prominent supplier specific strategies like SD (Chen et al., 2011). SD strategy ensures overall supplier support and improvement beyond the functional dimensions such as price, quality and delivery (Routroy and Kumar, 2015). But, from time immemorial the manufacturers have cultivated transactional relationships by over emphasizing the price factor alone (Smart, 2010). As suppliers were constantly questioned on the cost structures, pressurized to reduce the prices and were implicated with unreasonable demands, many manufacturer-supplier relationships are not thoroughly evolved and in turn suppliers' capabilities were not nurtured (Lloyd and James, 2008 and Rutherford and Holmes, 2008). Moreover, with the tightened profit margins and being in the competitive markets, some of the suppliers also succumbed to violate the ethical business codes of conduct mainly due to the fear of running out of the business (Herrigel, 2004 and Rutherford and Holmes, 2007). At times the increased buyer's pressure on the suppliers is also transformed in the form of greatly reduced wages, unsecured employment and even endangered working conditions at the suppliers' end (Delaney et al., 2015). This in turn indeed not only diluted the healthy supply chain competition but also greatly jeopardized the customers' conscience and interests at large. While a section of genuine suppliers could not survive, this led to the scarcity of good suppliers who could have competitively met the ever increasing demands of the customers. Having these experiences, though the manufacturers choose to propose mutually benefitting SD initiatives the suppliers tend to perceive the manufacturers as diplomatic and exploitative. Nonetheless, onus lies on the manufacturers to competitively convince their suppliers that the SD initiatives are win-win propositions. Also, the SD practices have to be systematically propagated beyond the tier-1 suppliers to ensure overall supply base development. This is affirmed by Hartmann and Moeller (2014) that the manufacturers must ensure that SD is realized and penetrated into the depths of backward linkages of the supply chains (which are mostly rooted in the developing countries).

Keeping the above discussion in mind, the excerpts of various researchers' explorations about the essential factors that drive the SD execution and extension are presented as follows: Watts and Hahn (1993) established that 'supplier evaluation' is a vital factor for achieving success in SD programs and they suggested that the manufacturer must have a systems at place to timely and accurately monitor the improvement of suppliers. Krause and Ellram (1997) conducted a survey to investigate the factors contributing to the SD success. They found that the 'proactive philosophy regarding the suppliers' performance', 'more effort and resource investments into the SD efforts', and 'exhibition of greater willingness to share information with the suppliers' enabled the satisfaction in SD. Krause (1997) found 'direct firm involvement', 'incentives commitment: if supplier improves' and 'enforced competition: no commitment' as main factors in improving a supplier's performance through SD. Krause and Scannell (2002) carried out a survey to compare the SD practices in product based and service based companies and found that in product based companies the 'assessment', 'incentives' and 'direct involvement' are more critical elements and in service based companies 'competitive pressure of the markets' is the driving force. Wen-li et al. (2003) examined the role of SD and its elements by conducting a survey of electronic companies in Honkong and identified that the 'long-term strategic goals', 'effective communications', 'partnership strategy', 'top management support', 'supplier evaluation', 'direct SD' and 'perception of supplier's strategic objective' are relevant. They concluded that the 'direct SD' and 'supplier's strategic objectives' are most significant for successful SD. Sánchez-Rodríguez et al. (2005) conducted a survey to determine how the SD practices at different complexity levels improve the purchasing performance and mentioned that 'supplier involvement in SD activities' increases the manufacturer's purchasing performance. Wagner (2006) conducted a survey on SD practices and mentioned that 'cooperative long term manufacturer-supplier relationships' can make a SD successful and indeed this safeguard a manufacturer from the supplier becoming opportunistic and secure its SD investments. Modi and Mabert (2007) advocated on the aspect of 'management involvement' and mentioned that the 'bi-lateral top management involvement from both supplier and manufacturer' in the SD efforts leads to successful SD programs. They also said that fundamentally the success SD programs is based on the 'evaluation and certification of the suppliers'. Matook et al. (2009) presented and supported a supplier risk management framework and mentioned that "knowledge sharing" as an important success factor that transcends the transactional relationships with the suppliers to cooperative relationships. Although the significance of SD factors cited through the above mentioned empirical studies may be relevant to the developing country like India but there was no explicit study conducted in this regard. However, few case studies conducted in the Indian manufacturing environment are reported in the literature as follows: Govindan et al. (2010) conducted a case study in an automobile firm by considering fifteen SD criteria and proposed an SD framework. Routroy and Pradhan (2013) identified and evaluated the importance of thirteen critical success factors of SD by conducting a case study in an Indian manufacturing company. Routroy and Sunil Kumar (2014) also conducted a case study in an Indian manufacturing company and analyzed the relationship between various SD enablers. Commonly in all these case studies, authors have expressed that the obtained framework was for a single company and the same can be extended by considering more companies from different industries for better understanding of SD variables and their relationships. Thus in this study, a questionnaire was developed (see appendix) along the SD enablers, conducted a survey in the Indian manufacturing environment and developed an SD furtherance model for achieving the systematic SD execution and extension. Further, the diagnosis of model was carried for analyzing the combined effects of the model variables through Bayesian networks.

5.3 Research methodology

The current study is mainly aimed at developing an SD furtherance model and carrying out an essential diagnosis that unfolds certain logical directions to emulate. In the present study, the methodology followed mainly has three phases to ponder i.e., establishing a SD furtherance measurement model, hypothetical testing of the directed relationships and developing a structural framework of SD furtherance and conducting further diagnosis of structural framework to obtain the probabilities of combined effects.

5.3.1 Identifying the principal components driving SD furtherance using PCA analysis

In conducting the study, a questionnaire (see appendix) was prepared along the SD factors that enhance the execution of SD and its extension. The questions framed were based on the literature review, brain storming sessions and discussions held with the academic and industry experts in India. Initially, a pilot study was conducted by sharing the early form of the questionnaire with a small group of industry experts drawn from the manufacturing companies in India to get the first response about the content in the questionnaire, its readability and the length of the questionnaire. Based on the initial responses, the redundant questions were eliminated and the length of the questionnaire was shortened in such a way that the requisite information is extracted within short period of time. The questionnaire was shared and discussed with the industry experts through personal interviews (during several industrial visits), telephonic conversations, audio calls made on internet, web meetings, emails, shared online spread sheets, meetings at industrial conferences and even by posting the hard copies of the questionnaire. The companies visited for conducting personal interviews were mainly located in Telangana (Hyderabad), Andhra Pradesh (Anantapur and Vizag), Tamilnadu (Chennai), Gujarat (Jamnagar, Ahmedabad, Surat and Vadodara), Maharashtra (Pune), Haryana (Rhothak), Karnataka (Belgaum and Bangalore) and Rajasthan states of India. For communications through other modes, the details of the industry experts were accessed from the databases of Confederation of Indian Industries (CII) and Gujarat Industrial Development Corporation (GIDC). The experts consulted were mostly designated as procurement and supply heads, general managers, assistant general managers, senior managers, supplier quality engineers, senior engineering managers, SD officers (or) engineers (or) managers. The overall designations of the sample of experts contacted and their industry wise representation along the sample are shown in the Table 5.1 and Table 5.2 respectively. The average experience of the experts consulted was more than eight years in the industry and were holding professional degrees in engineering and business administration. Overall around 1560 number of experts were asked to express their opinions but out of which 390 responses were obtained. After performing the data cleaning (using statistical software SPSS 20) only 356 responses were found to be valid with overall response rate of 22.82%. It was decided that the sample size of 356 responses would be sufficient to conduct the analysis as it is more than ten times the number of questions framed which are also termed as observed variables. Before carrying out the factor analysis on the collected data, it is essential to check whether it is meaningful to conduct it or not through Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's test of sphericity and anti-image correlation matrix. In this regard, the data used for analysis has shown high degree of correlation between the variables as the KMO measure obtained was 0.916 which should be at least 0.7 (see Table 5.3) and P-value under Bartlett's test of sphericity shown that it was significant (see Table 5.3). Even anti image correlation matrix was having negative partial correlations with its diagonal elements all greater than 0.5

while the lowest value was 0.785 (> 0.5). Since there was strong evidence about the presence of underlying dimensions it was decided to conduct factor analysis.

Table 5.1 Levels of respondents participated in the study

Level	Frequency	Percentage
Engineer/ Assistant Manager level	120	33
Senior Engineer/ Manager level	145	41
General Manager /Chief Engineer level	66	19
Purchasing and supply heads and above	25	7
Total	356	100

Table 5.2 Industry wise frequencies of the respondents participated in the study

Company Type	Industry Group	Frequency	Percentage (%)
Automotive	1	51	14
Electronics	2	46	13
Aerospace	3	45	12
Industrial equipment	4	42	12
Energy equipment manufacturing	5	38	11
Non-durable consumer products	6	36	10
Materials and Construction	7	35	10
Pharmaceuticals and biotechnology	8	24	7
Food, Beverage	9	21	6
Metals and Mining	10	18	5
Total		356	100.0

Table 5.3 Kaiser-Meyer-Olkin and Bartlett's test results

Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy		.916
Bartlett's Test of Sphericity	Approx. Chi-Square	14609.317
	Degrees of Freedom	561
	Significance	.000

5.3.2 Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) is a multi variate analysis technique used to reduce the data set by exploring the underlying pattern in the data. It groups the observed variables on the basis of their correlations into previously unknown smaller dimensions without compromising much of the information. Basically, these reduced dimensions (called as components or factors) are obtained by various extraction and rotation methods. Here, the most commonly applied methods namely Principal Component Analysis (PCA) for extraction and Varimax for rotation are used in identifying the major dimensions which are termed as principal components/ latent variables. After applying EFA, it was observed from the output that principally six components which explain the maximum variance of the variables around 78.964% were extracted (see Table 5.4). These latent variables were broadly named as Manufacturer's Response in SD (MRSD), Buyer-Supplier collaborative efforts (BSCE), Supplier Development Practice and Reach (SDPR), Supplier Motivation Strategies (SMST), Buyer-Supplier Understanding (BSUD) and Supplier Conduct and Status (SCST) based on the characteristics of underlying observed variables. The number of components extracted was according to the Kaiser criterion which was set to pick out the components having the Eigen values greater than 1. Further, the Scree plot shown in the Figure 5.1 also confirms that six components were extracted which were having Eigen values greater than 1. The correlations between the observed variables and the components extracted are shown in the form of factor loadings in the component matrix of SPSS output. The row-wise sum of the squares of these factor loadings would give the communalities (i.e. variance explained by the observed variables) of the observed variables and the column-sum of the squares of factor loadings would give the Eigen values (i.e. variance explained by the components/ latent variables) (Janssens et al., 2008). Components with factor loadings greater than 0.5 were considered to be significant in the current study. The obtained factor loadings that were particularly grouped under the respective components were more prominent than 0.5 and this was clearly evident from the rotated component matrix. It was ensured that there were no cross loadings along the variables (i.e. none of the variables grouped under a component has a correlation greater than 0.4 with other components). At this juncture, the reliability analysis was conducted to explore the consistency of the variables in defining a component (also called as latent variable) by estimating the Chronbach’s alpha value. Generally, the alpha value more than 0.70 is considered to be acceptable to proceed further with the data analysis. The obtained estimates of Chronbach’s alpha for the six latent variables were MRSD - 0.971, BSCE - 0.953, SDPR - 0.947, SMST - 0.843, BSUD - 0.945, and SCST - 0.926. These reliability statistics shown that there was internal consistency between the observed and latent variables. Generally, EFA is called as a technique that is usually used to prepare the data for further analyses.

Table 5.4 Total variance explained along the components extracted

Total Variance Explained									
Component	Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	15.221	44.768	44.768	15.221	44.768	44.768	5.364	15.775	15.775
2	3.643	10.715	55.483	3.643	10.715	55.483	5.041	14.827	30.602
3	2.754	8.101	63.583	2.754	8.101	63.583	4.535	13.338	43.940
4	2.316	6.812	70.396	2.316	6.812	70.396	4.258	12.522	56.462
5	1.533	4.510	74.905	1.533	4.510	74.905	4.125	12.133	68.595
6	1.288	3.789	78.694	1.288	3.789	78.694	3.434	10.099	78.694

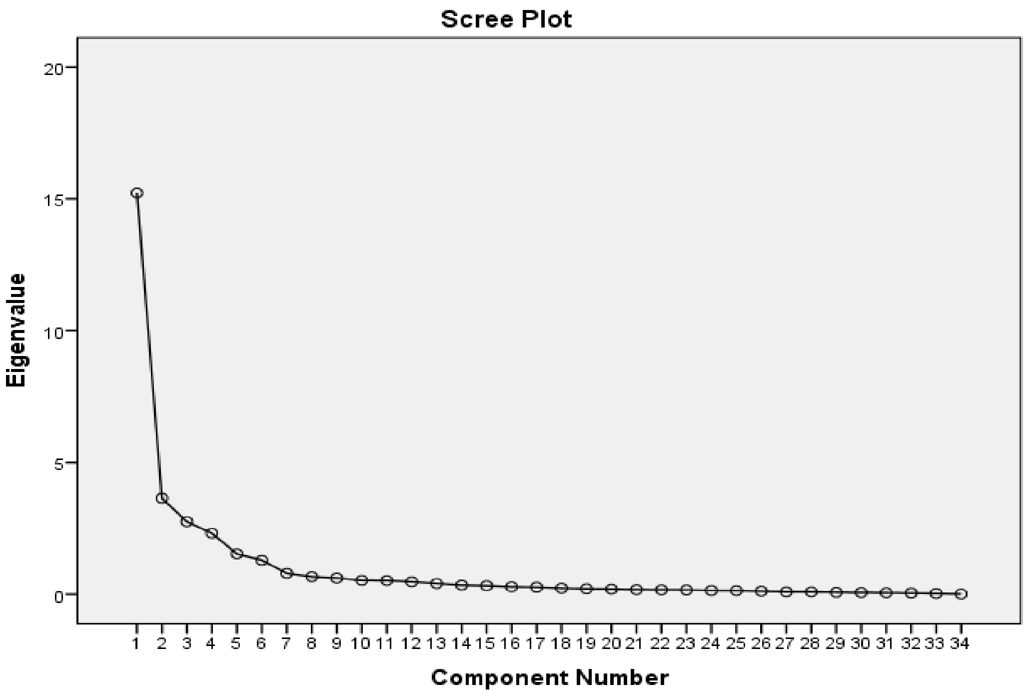


Figure 5.1 Scree plot showing the extraction of principal components

5.3.3 Confirmatory Factor Analysis

After exploring the underlying factors by EFA, the Confirmatory Factor Analysis (CFA) was performed to endorse the factors with their corresponding observed variables and examine the correlations between the latent factors. CFA is used to determine whether the observed variables are good enough in measuring the extracted components. The analysis was started with the model of 34 variables under six components. The initial model specifications obtained were χ^2 = 2918.359, df = 512, χ^2/df = 5.700, GFI = 0.686, AGFI = .635, RMSEA = 0.115, CFI = .835, RMR = 0.052. Since these model specifications do not satisfy the permissible limits mentioned in the Table 5.5, it was re-specified. The model was continuously refined with reference to Wang and Ahmed (2004) till the model fit indices were achieved in accordance to the permissible limits. For refining the model, the residual covariance matrix has to be checked first and ascertain that no value is greater than |2.58| (Janssens et al., 2008). From the obtained output, the highest value of residual covariance matrix was 0.146 < |2.58| therefore there was no means to refine the model on the basis of residuals. There were certain modification indices suggested in the output obtained through the calculation of estimates in AMOS 20. Based on the suggested modification indices, the model was refined by addressing the one that offered highest improvement (i.e. reduction in the discrepancy of estimated model) in the model. The model refinement was further done by removing the items with poor multiple correlations and low regression weights. After refining the model, the obtained model specifications were χ^2 = 284.263, df = 151, χ^2/df = 1.883, GFI = .927, AGFI = 0.898, RMSEA = .050, CFI = .980, RMR = .028. These refined model specifications were fitting the permissible limits and hence the refined model was considered as fit to estimate (see Table 5.6). After achieving the model fit, the essential checks namely, unidimensionality (Janssens et al., 2008), convergent validity (Anderson and Gerbing, 1988), reliability (Gaskin, 2012) and discriminant validity (Hair et al., 2006) conditions were performed for the variables to ensure that authentic decisions were made based on the data analysis. Under unidimensionality, it was checked whether or not the observed variables have stronger loading on the latent variables. To ensure unidimensionality the essential condition to be satisfied is t-value > 1.96 and in current study the obtained lowest of the t-values was 12.22 (> 1.96) which confirmed that there was unidimensionality. In convergent validity check, the standard regression coefficients between the observed and latent variables should be more than 0.5 (Janssens et al., 2008). Since the obtained lowest value was 0.626, the condition for convergent validity was satisfied. Under reliability check, the composite reliabilities of all the latent variables should be more than 0.7 (Gaskin, 2012). The obtained composite reliabilities for the latent variables were SMST - 0.847, MRSD - 0.954, BSCE - 0.917, SDPR - 0.894, BSUD - 0.925, SCST - 0.906, where all were greater than 0.7. Finally, the discriminant validity check was performed by examining that the square of a correlation between the variables is less than the Average Variance Explained (AVE) (Gaskin, 2012). Table 5.7 shows that all the squared correlations are less than AVE by the latent variables mentioned along the diagonal. Having fulfilled the conditions of unidimensionality, convergent validity, reliability and discriminant validity, the measurement model was fit for making authentic decisions. Figure 5.2 mentioned below shows the obtained measurement model after conducting the confirmatory factor analysis.

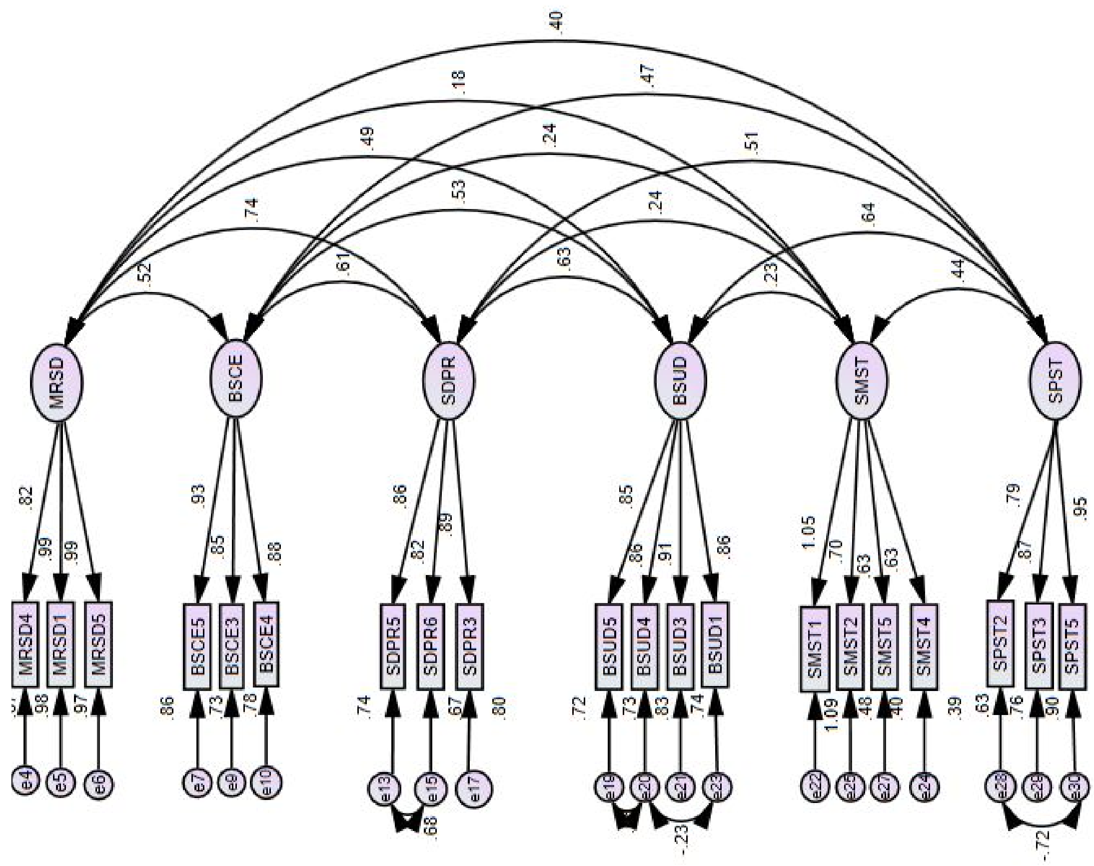


Figure 5.2 Confirmatory factor analysis conducted out for fitting the measurement model

Table 5.5 Permissible model fit indices indicating the quality of the model

Model parameters	SM integration	Permissible range	Citation
$\chi2/df$	1.163	≤3	Hu and Bentler (1999); Steiger (1990); Byrne (2013)
GFI	0.998	≥0.90	Mulaik et al. (1989)
AGFI	0.971	≥0.80	Bentler (1990); Hu and Bentler (1999)
RMSEA	0.026	≤0.10	Browne and Cudeck (1992)
CFI	0.999	≥0.90	McDonald and Marsh (1990)
RMR	0.087	≤0.14	Steiger (1990); Byrne (2013)

Table 5.6 Regression estimated weights of latent and measured variables

Measured Component	Directional relationship	Latent component	Estimate	SE	CR	P
MRSD4	⟵	MRSD	1			
MRSD1	⟵	MRSD	1.173	0.045	26.136	***
MRSD5	⟵	MRSD	1.15	0.044	25.943	***
BSCE5	⟵	BSCE	1			
BSCE3	⟵	BSCE	0.885	0.038	23.002	***
BSCE4	⟵	BSCE	0.912	0.037	24.545	***
BSUD5	⟵	BSUD	1			
BSUD1	⟵	BSUD	1.162	0.058	20.163	***
BSUD4	⟵	BSUD	0.96	0.027	35.535	***
BSUD3	⟵	BSUD	1.181	0.054	22.005	***
SMST2	⟵	SMST	1			
SMST5	⟵	SMST	0.9	0.073	12.367	***
SMST4	⟵	SMST	0.919	0.075	12.22	***
SPST3	⟵	SPST	1			
SPST5	⟵	SPST	1.083	0.05	21.599	***
SPST2	⟵	SPST	0.896	0.055	16.15	***
SMST1	⟵	SMST	1.315	0.08	16.387	***
SDPR5	⟵	SDPR	1			
SDPR3	⟵	SDPR	1.121	0.057	19.838	***
SDPR6	⟵	SDPR	1.016	0.03	33.359	***

Table 5.7 Average variance explained by the latent variables

	SMST	**MRSD**	**BSCE**	**SDPR**	**BSUD**	**SPST**
SMST	0.749					
MRSD	0.222	0.911				
BSCE	0.208	0.518	0.962			
SDPR	0.232	0.789	0.591	0.857		
BSUD	0.231	0.523	0.526	0.628	0.869	
SPST	0.336	0.402	0.396	0.467	0.660	0.964

5.4 Hypothetical testing of the directed relationships using path analysis

Based on the obtained principal components and their corresponding variables to measure, the directed causal relationships between the components can be examined using structural equation model/ path analysis. In order to test the significance of relationships between the components, six hypotheses were formulated through brainstorming sessions and in consultation with the academic and industry experts. The hypotheses tested using the path analysis are mentioned below,

H1: *Improved manufacturer's response in SD has a significant positive impact on buyer-supplier collaborative efforts.*

H2: *Improved manufacturer's response in SD has a significant positive impact on the supplier motivation strategies.*

H3: *Improved buyer-supplier collaborative efforts has a significant positive impact on the buyer-supplier understanding.*

H4: *Improved supplier motivation strategies has a significant positive impact on the Supplier Conduct and Status.*

H5: *Improved Supplier Conduct and Status has a significant positive impact on the buyer-supplier understanding.*

H6: *Improved buyer-supplier understanding has a significant positive impact on supplier development practice and reach.*

The components with the causal relationships according to the abovementioned hypotheses were constructed and analyzed using the AMOS 20. The estimates for the model along the relationships to be tested were calculated on the basis of previously collected data. Despite the relationships between the components, the constructed model must be fit with a p-value < 0.05. The hypothesized model along the latent variables and their corresponding measuring variables was constructed as path diagram in the AMOS 20. After calculating the estimates, it was found that the model was fit with the p-value at .002. Even the regression weights of the tested relationships along all the laid paths between the components shown significant relationship (see Table 5.8). Further, the model indices indicating the quality of the model obtained were χ^2 = 211.066, df = 154, χ^2/df = 1.371, GFI = .946, AGFI = 0.927, RMSEA = .021, CFI = .992, RMR = .021. These indices were acceptable with reference to the permissible levels. Hence, it was concluded that the constructed model is statistically valid to follow in the Indian manufacturing environment. Figure 5.3 mentioned below shows the obtained statistically validated SEM.

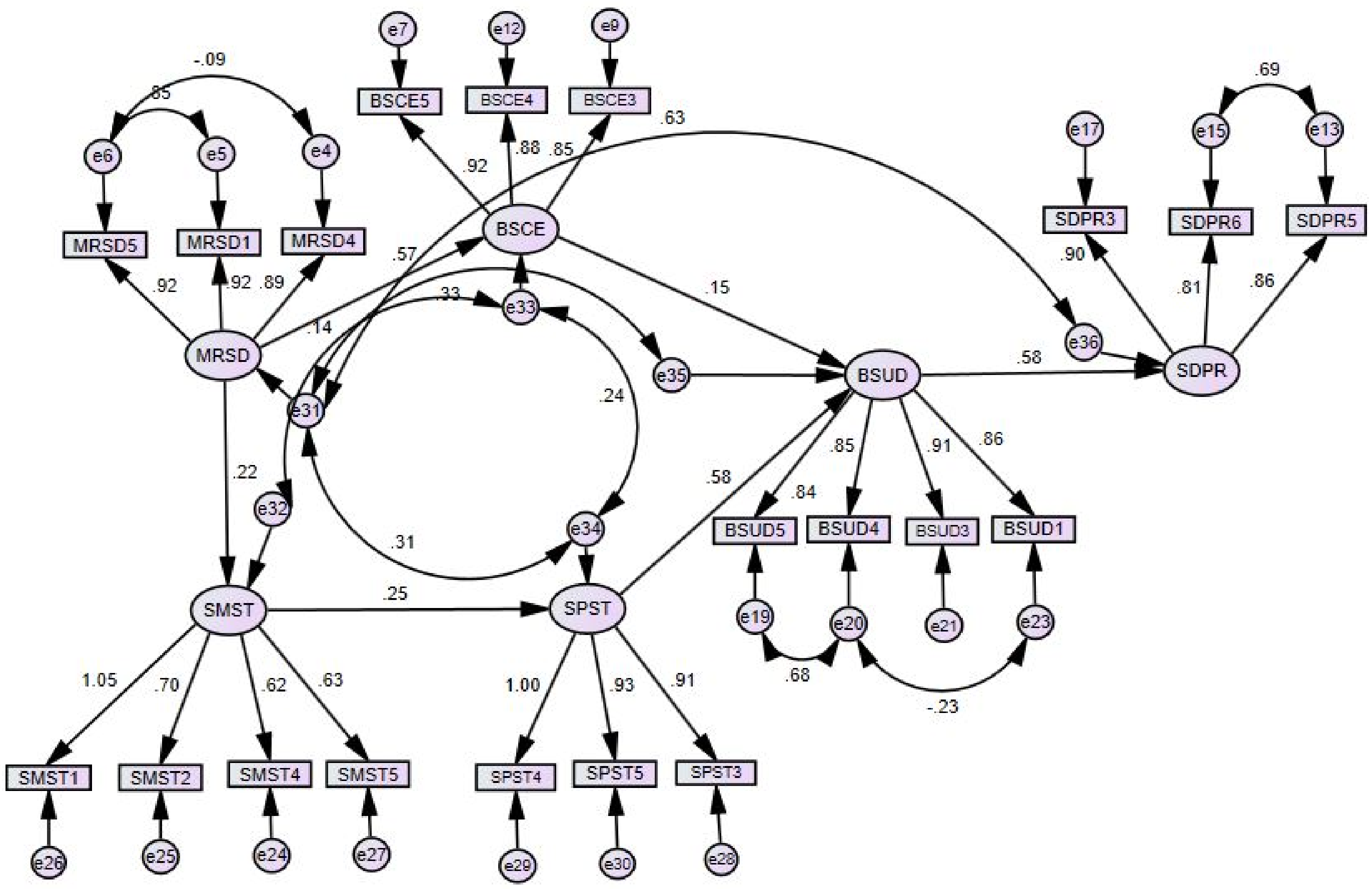


Figure 5.3 Path analysis conducted to test the significance of directed relationships

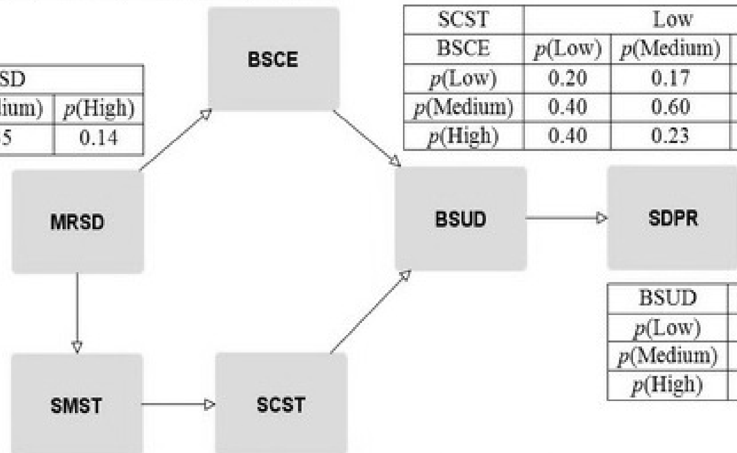
Table 5.8 Estimated Regression weights after testing the hypothesized relationships

Measured Component	Directional relationship	Latent component	Estimate	SE	CR	P
SMST	⟵	MRSD	0.081	0.02	4.139	***
SPST	⟵	SMST	0.391	0.076	5.175	***
BSCE	⟵	MRSD	0.378	0.035	10.859	***
BSUD	⟵	SPST	0.59	0.053	11.101	***
BSUD	⟵	BSCE	0.134	0.049	2.72	0.007
SDPR	⟵	BSUD	0.775	0.077	10.011	***

5.5 Diagnosis of structural framework to obtain the probabilities of combined effects

The structural framework obtained from the path analysis give whether a relationship is statistically significant or not. However, it does not give the levels of impact that the components have along the directed relationships. In this regard, Gupta and Kim (2008) proposed linking of SEM with Bayesian Networks (BNs) for effective diagnosis of the situations. The BN is a Directed Acyclic Graph (DAG) which enables a decision maker to analyze the combined effects of the variables along the laid causal relationships. In the current study, the empirically validated model was used as a reference in structuring the BN and the data collected for building the SEM was used to obtain the initial and conditional probabilities of the parent and child nodes respectively. For building the BN and obtaining the initial and conditional node probabilities, the AgenaRisk 6.2, R-programming and Microsoft-Excel were used. The node probabilities were determined by discretizing the latent factor scores which are obtained from the standardized respondent scores along the observed variables and their corresponding coefficients in measuring the respective latent factor. Discretization of data was carried into three states (low, medium and high) by dividing the range of data under an observed variable into three equal parts. Then correspondingly the respondents' ratings were transformed along the three states. Based on the frequency distribution of data along these states the initial and conditional probabilities were subsequently determined. The expressions used to calculate the node probabilities in the BN structure (see Figure 5.4) were P(MRSD), P(SMST/MRSD), P(BSCE/MRSD), P(BSUD/BSCE,SCST) and P(SDPR/BSUD). The conditional probabilities were determined by following the fundamental rule from Bayes' theorem i.e. P(H/E) = P(H,E)/P(E) where E is the evidence and H is the hypothesis updated on the basis of evidence E. Once, the calculated probabilities were entered into the node probability tables (see Figure 5.4), the influence of directed relationships along the BN were obtained. The Figure 5.5 shows the probabilities of the nodes obtained along the three states after running the calculation on the basis of node probability tables in the AgenaRisk 6.2 software. The obtained trends after conducting the sensitivity analysis of the BN are shown in the Figure 5.6 and Figure 5.7.

Figure 5.4 Bayesian network along with its node probability tables



MRSD		
p(Low)	*p*(Medium)	*p*(High)
0.51	0.35	0.14

MRSD	*p*(Low)	*p*(Medium)	*p*(High)
p(Low)	0.03	0.05	0.03
p(Medium)	0.85	0.80	0.67
p(High)	0.12	0.16	0.30

SCST	Low			Medium			High		
BSCE	*p*(Low)	*p*(Medium)	*p*(High)	*p*(Low)	*p*(Medium)	*p*(High)	*p*(Low)	*p*(Medium)	*p*(High)
p(Low)	0.20	0.17	0.00	0.33	0.10	0.04	1.00	0.14	0.00
p(Medium)	0.40	0.60	0.67	0.44	0.74	0.76	0.00	0.66	0.75
p(High)	0.40	0.23	0.33	0.23	0.16	0.20	0.00	0.20	0.25

BSUD	*p*(Low)	*p*(Medium)	*p*(High)
p(Low)	0.26	0.31	0.22
p(Medium)	0.46	0.36	0.45
p(High)	0.28	0.33	0.33

MRSD	*p*(Low)	*p*(Medium)	*p*(High)
p(Low)	0.27	0.05	0.10
p(Medium)	0.55	0.70	0.68
p(High)	0.18	0.24	0.23

SMST	*p*(Low)	*p*(Medium)	*p*(High)
p(Low)	0.30	0.15	0.16
p(Medium)	0.50	0.65	0.61
p(High)	0.20	0.20	0.23

Figure 5.5 Solved Bayesian network with probability distributions at various states

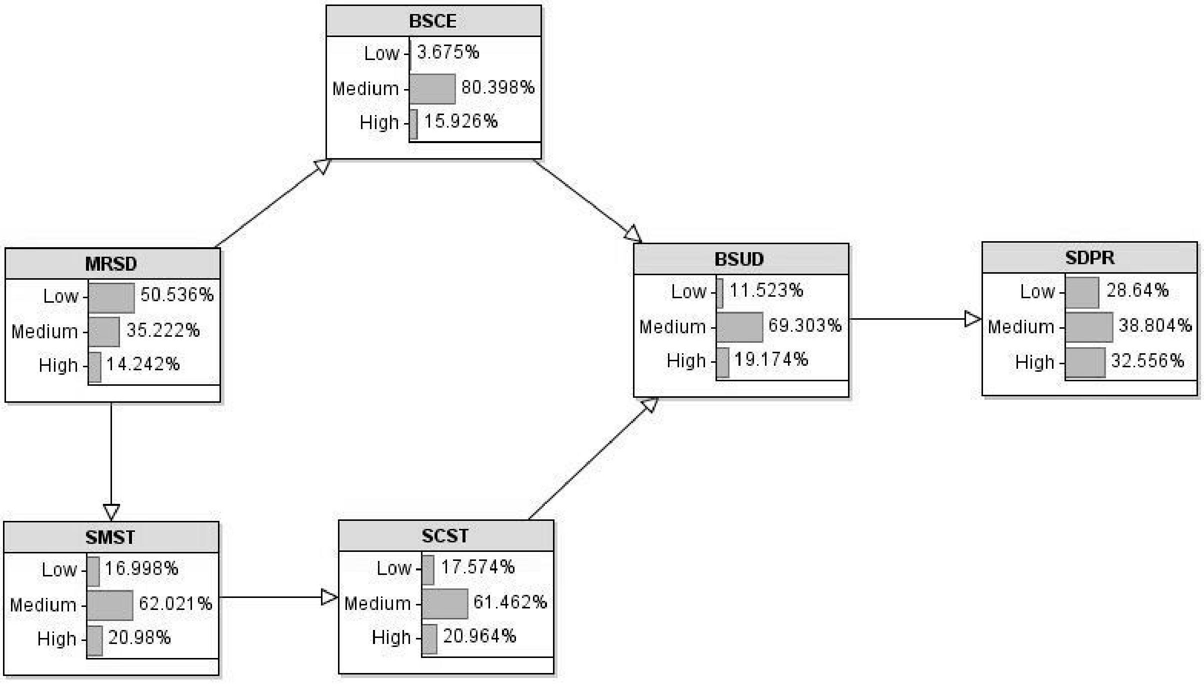


Figure 5.6 Sensitivity analysis of BSUD on SDPR

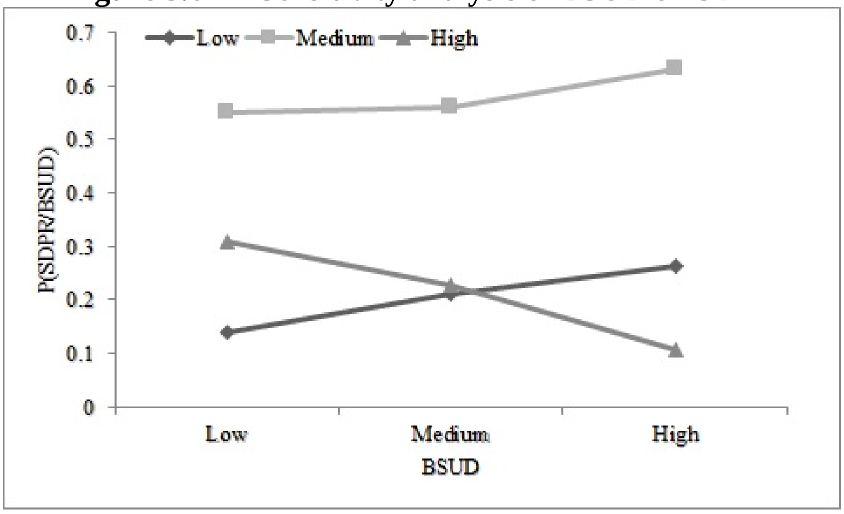
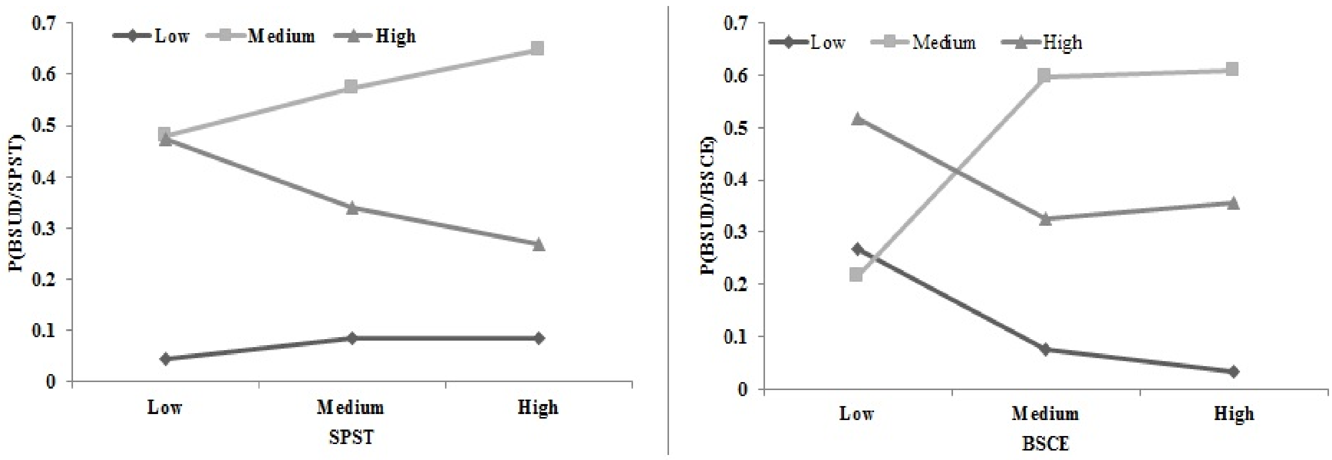


Figure 5.7 Sensitivity analysis of BSCE and SPST on BSUD



5.6 Results and discussions

The SEM constructed was proven to be valid on the basis of its obtained model fit indices. From, χ^2/df value at 1.371 (< 2) it can be inferred that the measurement model can be considered to be significant enough to generate data at par with the observed data. In other words, the covariance matrix generated from the measurement model is equivalent to the observed covariance matrix (which is the null hypothesis tested). The p-value also suggests that overall the measurement model is significant and the null hypothesis cannot be rejected. In the output obtained from the path analysis of the six principal components (extracted through PCA) also indicate that all the tested relationships (mentioned in the hypotheses H1-H6) are significant. From the standardized regression weights, it can be observed that the component SDPR is strongly influenced by BSUD and next to it is BSUD influenced by SCST. Although BSCE influencing BSUD is the lowest among the tested relationships (with respect to the obtained standardized regression weights), it is a statistically significant relationship. Having confirmed the existence of relationships along the causal paths of the SEM, mediation analysis was conducted along the relationships. From mediation analysis it was found that there were no mediation effects but indirect effects among the components. In order to conduct further diagnosis and analyze the combined effects along the relationships of the components the validated SEM was further structured as a BN.

Through BNs a decision maker can make forward inferences along the causal paths by making changes in the levels of components. With reference to the validated SEM, the components were positioned as nodes in the structured BN. The nodes were set at three states (low, medium and high) for analyzing their combined causal effects. In making the said forward inferences, the corresponding node probability tables were developed by discretizing the data collected in conducting the path analysis (see Figure 5.4). The solved BN with various probability distributions along the node states of each node is shown in the Figure 5.5. By setting the nodes at different states, the subsequent forward as well as backward inferences can be made. This corresponds to the sensitivity analysis in the AgenaRisk 6.2 and it enables a decision maker to understand the conditional influences of the nodes. The said sensitivity analysis was first carried out with SDPR as target node and BSUD as input node. Here, BSUD to SDPR was specifically chosen to carry out the sensitivity analysis as SDPR is the end effect of the BN and SDPR influenced by BSUD also had obtained strong regression weight (obtained from path analysis). Further, the influences of BSCE and SCST (as input nodes) on BSUD (as target node) were captured through sensitivity analysis. The obtained graph plots from the sensitivity analyses are shown in the Figure 5.6 and Figure 5.7. These figures also clearly show the existence of relationship between the components. From Figure 5.6, it can be seen that SDPR has an increasing trend from low to high when the BSUD is at low and medium levels. However, at higher state of BSUD, the SDPR shows decreasing trend. Thus, a manufacturer cannot go for higher levels of BSUD as it is detrimental to the SDPR furtherance. This is logical because by laying higher emphasis on BSUD beyond certain essential level leads a supplier to even comprehend the weaknesses of the manufacturers. This would provoke a supplier to become manipulative or even risky when there are certain terms not fulfilled in favor of the supplier. Thus with regards to BSUD, a manufacturer is recommended neither to put low level emphasis nor high level emphasis on BSUD for a better SDPR. While from Figure 5.7, it can be seen that BSUD almost remains constant from low to high when the SCST is at low level but at medium level of SCST the BSUD shows increasing trend from low to high. When SCST is at higher level, the BSUD shows decreasing trend from low to high. This is also indeed seen in practice (affirmed by industry experts) that the manufacturers had experienced increased resistance and conflicts from their suppliers by laying more emphasis on SCST. Even the good suppliers change their priorities in offering relationship based advantages against the manufacturer who is placing more emphasis on SCST than required. Thus, it was inferred that a manufacturer must neither operate at low level nor at high level of SCST for a better BSUD. From Figure 5.7, it can be understood that at low level of BSCE a manufacturer can only worsen the BSUD as there is a decreasing trend seen from low to high states. At medium and high levels of BSCE it can be noticed that BSUD follows almost mixed trends from low to high. This is understandable, because by assigning higher levels of emphasis on BSCE there would be an increased manufacturer’s dependency at a greater extent with a specific supplier. Moreover, a manufacturer is proportionately tied more and more with a supplier (which in turn increases supplier’s dominance) with increase in BSCE. So, a manufacturer has to operate at medium and high levels of BSCE but can expect that BSUD increases only to a certain extent and thereafter there would be a falling effect. These patterns in the Figures 6 and 7 clearly reflect the standardized regression weights obtained from the path analysis. The developed framework from path analysis and the results obtained from BNs would definitely assist a manufacturer in progressively running the SDPs.

5.7 Sectional summary

The SDPs are widely chosen and pursued by the manufacturers as they are proven to be the promising means to competitively position their supply chains. In this regard, an SD furtherance model was built in the Indian manufacturing environment using SEM and diagnosed it using BNs so as to assist a manufacturer in progressively running the SDPs. For developing the SD furtherance framework, a questionnaire was developed specifically focusing on the factors facilitating the SD execution and its extension along the manufacturing supply chain backward linkages. Thereafter, the questionnaire was administered to various manufacturing industry experts and their responses were recorded. On the basis of collected data, EFA was applied to extract the principal components (latent variables) overlaying the factors (observed variables) in the administered questionnaire and then the validity of the measurement model was established by carrying out the CFA. Then, hypotheses were developed along the directional relationships between the latent variables (which leads to SD furtherance) and were tested by conducting path analysis using SEM. The EFA, CFA and path analysis were conducted using SPSS 20 and AMOS 20. The obtained validated structural model after conducting the path analysis was taken as a reference and a BN was built to diagnose the combined effects of the latent variables. The BN was solved using AgenaRisk 6.2 and the corresponding node probability distributions along different node states were obtained. Further, sensitivity analyses were conducted to examine the influences of BSUD on SDPR, BSCE on BSUD and SCST on BSUD. Based on the obtained results from the sensitivity analyses, the corresponding graphical plots were developed. From the graphical plots, it was concluded that a manufacturer must pursue BSUD not beyond medium level for a better SDPR; SCST should be at medium level (i.e. it should be neither at low level nor at high level) for a better BSUD; and BSCE has to be preferably at medium level for a better BSUD. Finally, it was concluded that the developed framework using SEM and the results obtained from the BN analysis in achieving the SD furtherance are definitive in the Indian manufacturing environment. However, the results can be broadly applicable to most of the manufacturers with suppliers based in the developing countries. The current study has come up with the analysis of combined probable effects of the structural variables. It can be further extended to make it more dynamic in nature by incorporating the changes along the timeline and uncertainties.

This ends the chapter 5 dedicated for discussing the study conducted for developing an SD furtherance framework. In the next chapter, the generic frameworks developed for addressing the impediments to SDPs are discussed.

Chapter 6

Empirical study of Impediments to Supplier Development Programs

6 Sectional abstract

In the current scenario, the manufacturers' perspectives and their corresponding business practices in dealing with the suppliers have been vastly transformed and are evolving at a faster rate. Even supplier specific investments are committed for strategically developing and aligning the suppliers' capabilities so as to competitively meet the growing needs of the end customers. In this regard, Supplier Development (SD) has been proven to be one of the effective sourcing strategies that manufacturers can practice to befittingly mold their supply bases. However, operating on a global platform and having variegated interests among the stakeholders, the SD Programs (SDPs) have to deal with different challenges to ensure definite return on SD investments. Due to the ever increasing complexity of the supply chains, different circumstances are prescribing the course of SDPs. Thus in the current study, a pragmatic survey was conducted in Indian manufacturing industry to explore the interactions among the impediments to SDPs. The study has comprehensively incorporated the prominent impediments originate from different sides (i.e. supplier, manufacturer, manufacturer-supplier and external environment) and provided a basis for a manufacturer to effectively conduct the SDPs.

6.1 Necessity for empirical analysis of impediments to SDIs

Supplier Development (SD) strategy has been proven to be a promising approach for the manufacturers in establishing improved purchasing and supply management practices. Manufacturers are adopting SD strategy as a catalyst in order to extract best out of the contracts with the suppliers and in turn have desired sourcing alternatives established. Typically a manufacturer conducts SDPs with its key suppliers and proposes several SD initiatives in specific to the suppliers (Modi and Mabert, 2007). Individually the essential suppliers' capabilities are built in view of meeting its long-term needs as well as creating sustainable competitive advantages (Routroy and Pradhan, 2014). Most of the studies reported in the literature on SD have highlighted the performance improvement by adopting SDPs. Certainly as intended by a manufacturer an SD improves the targeted suppliers' performance in conformance to the manufacturer's requirements (Krause et al., 2000; Modi and Mabert, 2007; Routroy and Sunil Kumar, 2014). Sánchez-Rodríguez et al. (2005) empirically tested the effect of SD on purchasing performance and found that by implementing SD practices, the purchasing performance becomes more predictable. Kim (2006) focused on the effect of SD in improving the financial performance of a buying firm. Blonska et al. (2008) highlighted the role of SD in realizing a manufacturer's improved relationship performance (i.e. preferred buyer status) with a supplier having multiple competitive buyers. Lawson et al. (2015) propounded that, since SD enhances the suppliers' creative and innovative capabilities, there is performance improvement in the new product development. Gosling et al. (2015) established that by aligning SD initiatives with the suppliers positioned at higher level relationship categories has fetched consistency in the project performance. Routroy and Sunil Kumar (2015) also pointed out that SDP is a strategic alternative that a manufacturer can pursue to make its supply base competent and in turn have achieve overall improvement in the supply management performance. Having mentioned about the ability of an SDP to act as a catalyst for performance improvement, there are several impediments a manufacturer has to overcome in order to optimally realize the benefits from SD. Although SD is capable of offering better returns on SD investments, there are certain impediments which are diluting the effects of SDPs. On a global platform, manufacturers have to face certain concerns along with the advantages of outsourcing. Broadly, with regards to the concerns to deal with, a manufacturer has to operate in the manufacturing environments which are dynamic nature, adapt to the different circumstances prevailing at the stakeholders and have to meet the variegated perceptions and interests of the stakeholders. Research on SD has been evolving in the recent times, but hardly there are studies available that categorically and comprehensively addressed the impediments to SDPs especially in the context of developing countries like India. So in this study, the prominent concerns that are generally faced by the stakeholders while conducting the SDPs are explored on the basis of literature review, brain storming sessions and discussions held with the industry and academic experts. Thereafter, an empirical research was conducted to test the conceptually hypothesized directional relationships among the impediments to SDPs in order to reduce the negative impact on SDPs. The empirically validated models can greatly assist a manufacturer to fix the adverse effects in conducting the SDPs and have a basis to establish progressive environment for SD.

This paper is organized as follows: literature review on impediments to SDPs is presented in the Section 6.2; the research methodology followed in analyzing the impediments to SDPs is detailed in the Section 6.3; Section 6.4 features the questionnaire design, data collection and analysis; Section 6.5 contains the results and discussions; and Section 6.6 highlights the conclusions drawn from the interpretation of the results.

6.2 Literature review in support of framework for addressing the impediments to SDPs

As discussed in the previous section, the SD has been an effective way for a manufacturer to achieve performance improvement. Moreover, the competitive advantages derived through SD are very specific to a manufacturer as well as supplier and also the benefits of SD are long lasting. But, in practice there are certain impediments to SDPs which are hindering manufacturers in having progressive growth with the suppliers. Although impediments to SDPs are cautioned in various research studies, hardly any dedicated studies are available in the literature to efficaciously work on the probable shortcomings. Further, suppliers in Indian manufacturing environment are playing key role in most of the global supply chains. India has been increasingly attributed as a preferred sourcing destination for the foreign manufacturers to invest (EY, 2015). So, the current subject matter (i.e. modeling of impediments to SDPs) and the context of study (i.e. in the Indian manufacturing industry) can be of interest to most of the supply chain managers. The impediments to SDPs quoted by various researchers are broadly grouped under four categories namely, impediments to SDPs from supplier side, impediments to SDPs from manufacturer side, impediments to SDPs from manufacturer-supplier and impediments to SDPs from external environment are presented in the following subsections.

6.2.1 Impediments to SDPs from supplier side

Most of the research studies available in the literature have focused on the effects of a supplier's limitations on a manufacturer but did not concretely and comprehensively explored the possible impediments to SDPs from a supplier's perspective. In the developing countries like in India, the suppliers are often not very rich in the availability of resources and relatively have to work with high capital costs (Singh et al., 2007; and Sunil Kumar and Routroy, 2014). Suppliers having low purchasing power are highly cost conscious and are inclined to adopt reactive cost cutting procedures (Dunn and Young, 2004). Although it is essential to make the processes efficient, the attempts must not also go to the extent that the systems are prone to disruptions (Ponomarov and Holcomb, 2009). Nonetheless, constrained with resources, suppliers are concerned in adopting to the business transformations and show inherent inertia to accept manufacturer's SD initiatives (Handfield et al., 2006; Ahmed and Hendry, 2012; and Fu et al., 2012). Specifically for the suppliers, it is expensive, difficult to find and retain the skilled and experienced workforce despite in want (Huq et al., 2014, Mohanty et al., 2014; and Ağan et al., 2016). However, in practice human resources are mainly attracted to high remunerations and incentives, brand name of the company associated with, permanent job with security and rich exposure in the industry, which are very difficult for a supplier to offer. Due to these, a manufacturer as well as a supplier have difficulty with their suppliers' conditions and in turn are falling short of to effectively execute the SD initiatives (Panizzolo et al., 2012; and Routroy and Pradhan, 2014). Moreover, suppliers are inclined to adhere to their traditional procedures and retract to make changes in accordance to a particular manufacturer. In this regard, at times suppliers show non-compliance to a manufacturer's SD initiatives and revert back to the conventional procedures despite a manufacturer's strenuous insistence. Due to this kind of suppliers' mindset in SD is mostly favoring supplier switching rather than strenuously developing the supplier (Dunn and Young, 2004). Further, since traditionally the suppliers were not given strategic importance they tend to perceive a manufacturer as exploitative. Suppliers also exhibit complacence and apathy to a manufacturer's proposed initiatives in comparison to the benefits received from the manufacturer (Lascelles and Dale, 1990; and Mohanty et al., 2014). On the other hand, indeed suppliers are part of multiple supply chains with contradicting requirements (Raj Sinha et al., 2004), also become attractive to various customers' support (often competitors) and base their satisfaction in extending preferences to the manufacturers (Schiele et al., 2012). Thus suppliers are influenced to become biased and pose risks on a manufacturer viz. if a manufacturer is not perceived as a preferred customer (Raj Sinha et al., 2004; and Sunil Kumar and Routroy, 2015). Moreover, suppliers are implicitly evaluating their customers and are accordingly varying their performance (Hüttinger et al., 2012). Dissatisfied suppliers are having numerous complaints and keep arousing conflicts with a manufacturer's SD initiatives. Primarily, a dissatisfied supplier reasons unfairness in the business contracts, unreasonable demands and uncertainty in the future business from a manufacturer (Roloff and Aßländer, 2010; and Sunil Kumar and Routroy, 2014). Suppliers are also in a stew due to insufficient level of significance and in turn having approvals held back by the manufacturers despite their proposals are efficient and effective. As a result, suppliers are concerned about the investment of resources and their return on investments from a manufacturer and are apprehensive about a manufacturer's credibility (Lascelles and Dale, 1990; Mortensen and Arlbjørn, 2012; and Mohanty et al., 2014).

6.2.2 Impediments to SDPs from manufacturer side

Although a manufacturer takes initiatives to develop a particular supplier, certain impediments to SDPs were also originated from a manufacturer side. It is a manufacturer who essentially conducts SDPs, but often manufacturers do not have effective systems in practice to measure the performance of their suppliers, identify the areas of improvement, have specific performance objectives set and accordingly direct SD investments (Dunn and Young, 2004; and Routroy and Sunil Kumar, 2014). In most of the supplier audits, manufacturers do verify suppliers' standards through an essential check list of well-prepared questionnaire, but beyond auditing a supplier, a manufacturer has to effectively direct, support and fairly distribute the SD benefits to a supplier in the value addition process (Crosno et al., 2015). Payan and McFarland (2005) also highlighted that mere formal monitoring tools do not lead to supplier compliance rather they hinder the advantages from the suppliers. Akamp and Müller (2013) found that simply monitoring a supplier does not positively influence the supplier's performance. Since, there are no definite SD systems laid out in the practice, at times manufacturers are misguiding suppliers through incorrect, complex and uneconomical SD initiatives (Mohanty et al., 2014). Consequently, the chosen performance areas of improvement were not of advantageous to the manufacturer to instill the necessary drive in carrying out the SDPs. Suppliers who are to be developed are stressed and strained up by pursuing misguided SD initiatives and meeting the unessential SD targets. Even workforces are missing out to have a clear view regarding a manufacturer's requirements and its SD initiatives. Further, most of the manufacturers are rigid about the suppliers, lack supplier involvement and only look for conformance to their requirements without awarding essential power to freely contribute to their full potential (Galt and Dale, 1991; and Caniëls et al., 2013). This type of manufacturers' attitude is literally forcing suppliers to lose cost saving opportunities and are inherently developing intolerance against the manufacturers. Moreover, manufacturers are accumulating payables outstanding with the suppliers, detaining cash to cash cycles and are increasing additional costs (Routroy and Sunil Kumar, 2014). Therefore, while proposing SD initiatives if a manufacturer is not considerate about what a supplier is capable of and does not function in line with a supplier's requirements and interests then certainly it fails to profoundly convince a supplier to take part in SD (Mortensen and Arlbjørn, 2012). Among the suppliers' interests, the percentage of a supplier's output received by a manufacturer is certainly a determining factor (Krause and Ellram, 1997). Without putting emphasis on suppliers' interests, a manufacturer indeed become responsible for inciting opportunistic behavior among the suppliers. Another important issue often a manufacturer stands as a reason is, suppliers are not made aware of the intensity of losses occurred to a manufacturer due to the shortcomings in supplies (Sunil Kumar and Routroy, 2015). Manufacturers are often failing to create awareness among the suppliers about the basis for proposed SD initiatives and their associated advantages (Panizzolo et al., 2012). Overall these aspects are exemplify that purchasing is not given enough strategic importance, explicitly indicate that suppliers are not entrusted (where trust is a strong solution for most of impediments to SDPs) (Nagati and Rebolledo, 2013), lack adaptability along with the evolution of supplier relationships and ultimately fail to have effective coordination strategies with the suppliers (Panizzolo et al., 2012).

6.2.3 Impediments to SDPs from manufacturer-supplier side

In this section, the impediments to SDPs that usually from originate from both manufacturer and supplier are excerpted from various research works. Basically, most of the manufacturers and suppliers are not well informed and also lack responsiveness in transforming their manufacturing systems in accordance to the changing business trends, in keeping up with the rapidly evolving supply chain drivers and in adopting the industry best practices. Since the complexity of supply chains is continuously increasing, it is very challenging to have SD initiatives implemented without having continuously improved manufacturing systems. In this regard, rarely there is supportive information infrastructure and essential expertise to foresee the changes and have intelligent manufacturing systems designed and developed to optimally perform and resiliently endure through the effects of disruptions (Sharma and Bhagwat, 2006; and Panizzolo et al., 2012). The manufacturing systems at both manufacturer and supplier hardly have sufficient flexibility built in to accommodate the ups and downs and steadily back the SDPs. Due to these the workforces at manufacturer-supplier have daunting experiences in the mutual interactions with little regulation and conviction in implementing the SDPs (Wagner et al., 2005). Further, lack of emphasis from top managements, sporadic follow-ups and inadequate support in executing the SDPs are impeding the workforces to have essential motivation to contribute (Stuart, 1993; Panizzolo et al., 2012; and Routroy and Sunil Kumar, 2015). Manufacturer-supplier are rarely having talented (viz. in purchasing), satisfied and empowered workforce taking part in the SDPs. Without having developed workforces, implicitly it is a challenge to have effective communication and feedback channels established in conducting the SDPs while emerging through highly dynamic manufacturer-supplier relationships (Wagner et al., 2005; and Sunil Kumar and Routroy, 2014). Consequently, manufacturer-supplier are originating communication gaps, variegated perspectives, strategies, interests and competencies developed (Lascelles and Dale, 1990; Krause and Ellram, 1997; Modi and Mabert, 2007; and Prajogo et al., 2012). For instance, the most prominent difference in the perspectives to highlight is ‘lack of total cost perspective’ (Sunil Kumar and Routroy, 2014). Due to which in the manufacturer-supplier contracts, cost alone is relatively over accentuated by disregarding other important quality characteristics in the value addition process. They are also having differences acquired specifically in their supply chain and competitive strategies due to dissimilar organizational cultures (Ahmed and Hendry, 2012). Through these differences, eventually the proposed SD initiatives do not convey win-win situations for manufacturer and suppliers. Moreover, often the resource allocation and development made are not reciprocating in nature for each other owing to the aforementioned variegated differences (Blonska et al., 2013). These differences may further fragment manufacturer-supplier with meagre preferential relationships extended. As a result manufacturer-supplier may mutually cause longer waiting times in getting the orders processed and the issues resolved, increase the number of buyer-supplier conflicts, hinder the exchange of best supply chain flows and eventually increase their operations, quality and inspection costs (Narayanan et al., 2015). Having mentioned these deviations in between manufacturer-supplier, scarcely there may be unanimity expected in exploring, generating, materializing and also freely exchanging the innovative ways and advancements in the value addition process. Along with these, a manufacturer-supplier also certainly fail to see the value of mutual SD investments and become dissatisfied with the shared SD profits and risks while it is expected to further beyond profit and loss conceptions (Dunn and Young, 2004; and Sunil Kumar and Routroy, 2014). So, when win-

win situations are doubtful then instead of commitment in pursuing SD initiatives mostly risks, complaints and conflicts implicitly prevail in between manufacturer-supplier (Blonska et al., 2013).

6.2.4 Impediments to SDPs from external environment

In this section the prominent impediments to SDPs from external environment are focused. Mainly, the scarcity of resources is increasingly affecting the most of the manufacturing supply chains and so sustainability in the supply chains has become an important aspect both in research and practice. While SD is used as an attempt to make the supply bases more sustainable, there are certain issues that are affecting the effects of SD. Especially, numerous, incomprehensible and rigid rules and regulations are constraining as well as weakening the implementation of SD (Erkul et al., 2015). This is because not many manufacturing organizations have dedicated workforces disseminated with the comprehensive knowledge about the standards for sustainable manufacturing. So, even though there are some audits conducted timely, still there is no satisfying improvement achieved in the organizations. In addition to this, if there is no healthy competition developed (because of corruption and illegitimate practices) (Akamp and Müller, 2013) especially, in the case of manufacturers seeking same type of inputs then price and shortage pressures aggravate the ineffectiveness of SD. Further, a manufacturer-supplier though systematic and genuine may have to go through the unhealthy competition from others manufacturers who provoke the false competitive advantages with fraudulent practices (Rădulescu et al., 2010). This is even worsened with an unfavorable region of operation, where there cannot be supportive physical distribution system established with efficient and responsive logistics function (Iyer et al., 2006). In this regard, although the mutual visits help to have improved SD, still it is infeasible for most of the manufacturer-supplier to practice it regularly. It is also apparent that depending upon the region of operation, the societal impact also constrain the implementation of SD (viz. incapable, rigid and demanding local workforces must be employed and interests of general mass must also be fulfilled). So, while SD efforts are aimed to optimize the systems (inventory management for instance), the manufacturer-supplier are forced to consider the abovementioned dynamic constraints. Besides to mention among the issues against SD, certain compromising decisions detrimental to SD are also made at times due to political interference that deprive the control from manufacturer-supplier (Routroy and Sunil Kumar, 2014). Especially, the regional politics and their undesirable intervention may completely influence the expected effects of SD (Wagner et al., 2005). As a result essential drive, transparency and visibility are at stake in carrying out the SD activities. At times, the allegations from external agents (such as media, social forums and non-government organizations) become so intense that manufacturer-supplier have to deviate from the normal course of SDPs. As a result the changes in the support extended, taxes and tariffs levied, and amendments made due to political events at various levels of governments call for updating the SDPs (Trkman and McCormack, 2009). Further, in the case of high technology products (electrical, electronic and automotive) and agile manufacturing environments, the competition is high and customers are relatively more demanding, highly informed and disloyal. Due to which the product life cycles are highly compressed with unpredictable shifts in the interests and the strategies made in tackling these are rarely robust and as a result manufacturer-supplier lack clarity in the execution of SDPs (Handfield et al., 2006; and Trkman and McCormack, 2009). Overall, SD has to be implemented in the manufacturing systems that are subjected to abovementioned various external influences.

6.3 Research methodology

In this study, several questions related to impediments to SDPs were framed and a pilot study was conducted to have a meaningful data extracted. In conducting the said pilot study, a focused group of industry experts were approached to comment on the readability and comprehensiveness of the questions framed. Based on the experts' judgments, the questions framed on impediments to SDPs were broadly divided into the four sets of questionnaires (say Q_1, Q_2, Q_3 and Q_4 on the basis of their source of generation) namely under supplier side, manufacturer side, manufacturer-supplier side and from external environment (see Appendix). Most of the experts pointed out to have categorized set of questionnaires so as to comprehensively explore the impediments to SDPs. The set of questionnaires framed were simple, specific, short, strain free and did not consume much of experts' time to respond. The questionnaires were administered to a larger sample of procurement experts drawn from Indian manufacturing companies. The process of response data collected for the aforementioned questionnaires was carried out through direct interviews during industrial visits, video calls on internet, web meetings and interactions at the international conferences and industrial workshops. The direct interviews with the experts were lasted on an average of one and half an hour. Further, the questionnaires were shared online in the form of spread sheets and by posting the hard copies of the questionnaires. The contact details of the industry experts were obtained from the databases of Confederation of Indian Industries (CII) and Gujarat Industrial Development Corporation (GIDC). The set of questionnaires were administered to around 1560 number of experts and were pursued to complete the questionnaires with timely reminders. Overall around 284 responses were obtained with response rate of 18.2 %. Among the responses obtained for the four questionnaires, more than 35 % responses were collected through direct meetings with the experts and rest were through indirect modes of communications. The collected data along the set of questionnaires were processed using statistical software SPSS 20. After data cleaning, it was found that the response data was adequate minimally more than ten times the number of questions framed in each set of questionnaire. The designation wise frequency and the industry wise frequency of experts constituted in the samples are shown in the Table 6.1 and Table 6.2 respectively. The sample of experts consulted in the study were having professional degrees either in engineering or business administration. The experts were having more than ten years of experience in handling purchasing and supply management activities. The next section details the various analyses conducted on the data to extract certain logical conclusions.

6.3.1 Factor Analysis

In order to justify the application of factor analysis on the collected data, the essential tests namely Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's test of sphericity, and anti-image correlation matrix tests were conducted. Under KMO measure of sampling adequacy, the collected data shown high degree of correlation between the variables as the obtained lowest among the KMO measures was 0.882, where the valid value must be at least 0.7 (see Table 6.3). Under Bartlett's test of sphericity, the obtained p-values were also significant (see Table 6.3). Even under anti image correlation matrices were having negative partial correlations with their diagonal elements greater than 0.5 while the lowest values under Q_1, Q_2, Q_3 and Q_4 were 0.836, 0.828, 0.882, and 0.841 respectively. As the above mentioned tests were cleared, it was believed that there would be underlying dimensions to be explored through Exploratory Factor Analysis (EFA) is detailed in the next section.

6.3.2 Exploratory factor analysis

In conducting an EFA, the Principal Component Analysis (PCA) method along with varimax rotation method was used for extracting the underlying components that explain maximum of total variance in the data. The percentage of variance explained by the extracted components for four data sets are mentioned in the Table 6.4. The extraction of components is based on Kaiser Criterion which was set to filter the components with Eigen values greater than 1. The obtained factor loadings for the four sets of data are shown in the Table 6.5. These factor loadings were believed to be strongly related to the components extracted since all the values were more than 0.5. There were also no cross loadings for the factors with the other components as all the obtained values were less than 0.4. Finally, reliability analysis for the factors under extracted components was conducted and it was found that the reliability statistics Cronbach's alpha were all greater than 0.9 while the minimum value must be 0.7. Having extracted the component through an EFA, corresponding measurement models were estimated using Confirmatory Factor Analysis (CFA) as explained in the next section.

Table 6.1 Designation levels of respondents consulted in the current study

Level of respondent	Supplier side		Manufacturer side		Manufacturer-supplier side		External side	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Engineer/ Assistant Manager level	124	46	112	42	117	41	122	49
Senior Engineer/ Manager level	84	31	71	19	73	26	59	24
General Manager /Chief Engineer level	52	19	49	27	58	21	47	18
Purchasing and supply heads and above	14	4	33	12	33	12	22	9
Total	264	100	265	100	281	100	250	100

Table 6.2 Industry wise frequency distribution of respondents consulted in the current study

		Supplier side		Manufacturer side		Manufacturer-supplier side		External side	
Company Type	Industry Group	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)	Frequency	Percentage (%)
Automotive	1	71	27	49	14	53	14	55	14
Electronics	2	48	18	42	13	46	13	43	13
Aerospace and defense	3	18	7	12	12	22	12	18	12
Industrial equipment	4	45	17	36	12	34	12	33	12
Energy equipment manufacturing	5	20	7	35	11	32	11	28	11
Non-durable consumer products	6	18	7	31	10	35	10	23	10
Materials and Construction	7	15	6	33	10	22	10	20	10
Pharmaceuticals and biotechnology	8	12	5	19	7	15	7	14	7
Food, Beverage	9	9	3	3	6	12	6	11	6
Metals and Mining	10	8	3	5	5	10	5	8	5
Total		264	100	265	100	281	100	250	100

Table 6.3 KMO and Bartlett's test results

Statistics		Supplier side	Manufacturer side	Manufacturer-supplier side	External side
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.882	.911	.927	.913
Bartlett's Test of Sphericity	Approx. Chi-Square	9744.327	7581.626	10754.184	6344.277
	Degrees of freedom	231	210	325	231
	Significance	.000	.000	.000	.000

6.3.3 Confirmatory Factor Analysis

The CFA was applied on the components/ latent variables (extracted using EFA) and their corresponding observed variables in order to ensure that the observed variables befittingly estimate the variations in the components. On the basis of collected data, four measurement models were built and their specifications were checked against the acceptable levels (mentioned in Table 6.6). Initially the specifications of the models were not satisfying and hence, the models were further refined till the acceptable model specifications were achieved. The said refinement of the models was carried out by ensuring none of the values in the residual covariance matrix is greater |2.58|; addressing the suggested modification indices by AMOS 20; and by removing the items having relatively larger cross loadings, poor correlation coefficients and low regression weights (Wang and Ahmed (2004) and Janssens et al. (2008)). After fitting the models within the acceptable limits, they were subjected to several tests namely, unidimensionality (Janssens et al., 2008), convergent validity (Anderson and Gerbing, 1988), reliability (Gaskin, 2012) and discriminant validity (Hair et al., 2006) tests. The models were subjected to the aforementioned tests and was ensured that the necessary conditions were fulfilled. Under unidimensionality test the strength of observed variables for estimating the latent variables was confirmed by verifying that t-values are greater than 1.96. The convergent validity test was performed by ensuring that Average Variance Explained (AVE) is less than 0.5. For conducting the reliability test, the Composite Reliabilities (CRs) of the latent variables under four models were determined. It was found that the lowest of the obtained CRs was 0.908 which was greater than the 0.7 (a minimum expected reliability statistic value). Finally, the divergent validity test was conducted by comparing the square of a correlation coefficients between latent variables are less than AVE. It was found that there were no divergent validity concerns in the constructed measurement. Thus, after performing all the above mentioned tests it was believed that the models were fit to make authentic decisions without much discrepancy. The next section presents the hypotheses formulated on the basis of literature review and in the consultation with the industry experts.

6.4 Hypotheses to test the directed relationships among the latent variables

Having extracted the principal components among the impediments to SDPs on the basis of the underlying observed variables, certain hypotheses were developed in constructing the conceptual models. These hypotheses were developed on the basis of patterns conceived thorough literature review on the impediments to SDPs, brainstorming sessions, discussions held with industry and academic experts about their relevance. The following sub sections categorically detail the constructed null hypotheses for empirically testing their significance.

6.4.1 Conceptual model under supplier side category

H_{11}: *Supplier's resource incompetency increases ill effect of supplier’s supply and demand*

H_{12}: *Ill effect of supplier’s supply and demand lead to supplier's reluctance to manufacturer's initiatives*

H_{13}: *Ill effect of supplier’s supply and demand result in supplier's disengagement and dissatisfaction*

H_{14}: *Supplier's reluctance to manufacturer's initiatives result in supplier's disengagement and dissatisfaction*

6.4.2 Conceptual model under manufacturer side category

H_{21}: *Manufacturer's ineffective systems of operation lead to incorrect supplier selection and SD initiatives*

Table 6.4 Principal components extracted through exploratory factor analysis

Total Variance Explained Under Supplier Side									
Component	Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.757	53.441	53.441	11.757	53.441	53.441	5.406	24.573	24.573
2	3.181	14.458	67.899	3.181	14.458	67.899	5.276	23.981	48.554
3	2.766	12.573	80.473	2.766	12.573	80.473	4.346	19.754	68.308
4	1.071	4.867	85.34	1.071	4.867	85.34	3.747	17.032	85.34
Total Variance Explained of SDIs Under Manufacturer Side									
Component	Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.758	55.988	55.988	11.758	55.988	55.988	5.004	23.827	23.827
2	2.834	13.497	69.485	2.834	13.497	69.485	4.963	23.635	47.461
3	1.852	8.817	78.302	1.852	8.817	78.302	4.502	21.438	68.9
4	1.411	6.717	85.019	1.411	6.717	85.019	3.385	16.119	85.019
Total Variance Explained of SDIs Under Manufacturer-supplier Side									
Component	Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.959	49.844	49.844	12.959	49.844	49.844	4.967	19.102	19.102
2	3.48	13.386	63.229	3.48	13.386	63.229	4.598	17.687	36.789
3	2.612	10.048	73.277	2.612	10.048	73.277	4.588	17.645	54.434
4	1.874	7.207	80.484	1.874	7.207	80.484	4.191	16.121	70.555
5	1.597	6.14	86.624	1.597	6.14	86.624	4.178	16.069	86.624
Total Variance Explained of SDIs Under External Side									
Component	Initial Eigen Values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.972	49.871	49.871	10.972	49.871	49.871	4.202	19.099	19.099
2	2.949	13.403	63.274	2.949	13.403	63.274	3.986	18.12	37.219
3	2.007	9.124	72.398	2.007	9.124	72.398	3.622	16.465	53.684
4	1.677	7.622	80.02	1.677	7.622	80.02	3.455	15.704	69.389
5	1.03	4.68	84.7	1.03	4.68	84.7	3.369	15.311	84.7

Table 6.5 Rotation component matrices obtained for components extracted

Supplier Side				
Observed Variable	Component			
	1	2	3	4
SRIP4	0.93			
SRIP6	0.93			
SRIP1	0.93			
SRIP3	0.92			
SRIP5	0.84			
SRIP2	0.82			
SDDI4		0.9		
SDDI3		0.89		
SDDI5		0.88		
SDDI6		0.87		
SDDI2		0.87		
SDDI1		0.83		
SRMI3			0.85	
SRMI5			0.84	
SRMI2			0.83	
SRMI4			0.83	
SRMI1			0.77	
ISSD3				0.8
ISSD2				0.8
ISSD4				0.76
ISSD1				0.75
ISSD5				

Manufacturer Side				
Observed Variable	Component			
	1	2	3	4
LMAS5	0.87			
LMAS2	0.85			
LMAS4	0.84			
LMAS6	0.83			
LMAS3	0.82			
LMAS1	0.79			
ISSI5		0.9		
ISSI6		0.86		
ISSI2		0.82		
ISSI4		0.81		
ISSI3		0.8		
ISSI1		0.72		
MISO1			0.91	
MISO5			0.91	
MISO2			0.9	
MISO3			0.83	
MISO4			0.72	
MPSS2				0.84
MPSS3				0.83
MPSS4				0.81
MPSS1				0.8

Manufacturer-supplier Side					
Observed Variable	Component				
	1	2	3	4	5
OLWF5	0.91				
OLWF3	0.9				
OLWF1	0.89				
OLWF2	0.89				
OLWF4	0.89				
PCMS5		0.86			
PCMS4		0.84			
PCMS2		0.79			
PCMS6		0.77			
PCMS3		0.75			
PCMS1		0.69			
IUMS1			0.94		
IUMS3			0.94		
IUMS4			0.92		
IUMS5			0.89		
IUMS2			0.89		
USRS2				0.88	
USRS3				0.86	
USRS1				0.83	
USRS5				0.8	
USRS4				0.8	
PBSA2					0.85
PBSA3					0.84
PBSA4					0.83
PBSA5					0.81
PBSA1					0.76

External Side					
Observed Variable	Component				
	1	2	3	4	5
UIEA5	0.89				
UIEA4	0.88				
UIEA3	0.84				
UIEA2	0.8				
UIEA1	0.76				
UUSC2		0.82			
UUSC5		0.79			
UUSC4		0.79			
UUSC3		0.78			
UUSC1		0.72			
RPMS2			0.87		
RPMS3			0.87		
RPMS4			0.85		
RPMS1			0.73		
UCSR3				0.91	
UCSR2				0.85	
UCSR4				0.84	
UCSR1				0.79	
UURO1					0.88
UURO2					0.86
UURO3					0.86
UURO4					0.84

Table 6.6 Permissible ranges for the model parameters that ensure high quality

Model parameters	Citation	Permissible range	Supplier side	Manufacturer side	Manufacturer-supplier side	External side
$\chi 2/df$	Hu and Bentler (1999); Steiger (1990); Byrne (2013)	≤3	2.335	2.57	1.825	2.128
GFI	Mulaik et al. (1989)	≥0.90	0.91	0.911	0.912	0.9
AGFI	Bentler (1990); Hu and Bentler (1999)	≥0.80	0.875	0.869	0.881	0.871
RMSEA	Browne and Cudeck (1992)	≤0.10	0.071	0.077	0.021	0.067
CFI	McDonald and Marsh (1990)	≥0.90	0.981	0.976	0.983	0.974
RMR	Steiger (1990); Byrne (2013)	≤0.14	0.087	0.034	0.054	0.036

H_{22}: Manufacturer's ineffective systems of operation lead to lack of manufacturer's affirmation to a supplier

H_{23}: Incorrect supplier selection and SD initiatives cause lack of manufacturer's affirmation to a supplier

H_{24}: Lack of manufacturer's affirmation to a supplier results in manufacturer's poor supplier staking

6.4.3 Conceptual model under the category of manufacturer-supplier side

H_{31}: Insensitive and unreliable management systems are reason for oppressed and limited work force

H_{32}: Oppressed and limited work force lead to poor buyer-supplier alignment

H_{33}: Oppressed and limited work force lead to poorly connected manufacturing systems

H_{34}: Poor buyer-supplier alignment contribute to uncoordinated systems of resource sharing

H_{35}: Poorly connected manufacturing systems contribute to uncoordinated systems of resource sharing

6.4.4 Conceptual model under external environment

H_{41}: Increased unhealthy competition and scarcity in resources instigate unscrupulous internal and external agents

H_{42}: Unusual and unstable regions of operation instigate unscrupulous internal and external agents

H_{43}: Increased unhealthy competition and scarcity in resources lead to unpredictable and uncertain supply chains

H_{44}: Unusual and unstable regions of operation lead to unpredictable and uncertain supply chains

H_{45}: Unscrupulous internal and external agents lead to unpredictable and uncertain supply chains

H_{46}: Unpredictable and uncertain supply chains further risk prone manufacturing systems

6.5 Path analysis of conceptual models

The path analysis was conducted in order to validate the conceptualized models and test the significance of hypothesized relationships among the latent variables (discussed in the previous section). On the basis of laid hypotheses under respective categories, the conceptual models were constructed as path diagrams in AMOS 20. These path diagrams were used for analyzing the conceptually conceived relationships on the basis of empirical data collected. As discussed earlier, in order to make certain reliable decisions from a model, the proposed model must be fit enough for making the correct estimates without significant discrepancy. The calculated estimates for the path diagrams (under all aforementioned four categories), clearly shown that the p-values (indicating that the probability to have discrepancy in the estimates was close zero) stand significant. Further, the obtained regression weights along the hypothesized relationships were also significant (see Table 6.7). The obtained fit indices also demonstrated that the conceptual models were appropriate with acceptable quality (see Table 6.6). Figures 1-4 show the path diagrams along with their calculated estimates. Finally, to ensure that the reliability, convergent validity and discriminant validity thresholds were fulfilled, the CRs for the latent factors, the correlation matrix between the latent factors, and their AVE were determined respectively. The models were found to be good enough to undertake in dealing with the impediments to SDPs. The obtained statistical measures are shown in the Table 6.8. The models can be used as structural frameworks by the manufacturers operating in an Indian manufacturing environment to have well organized SDPs as well as to develop effective mitigation strategies to address the impediments to SDPs.

Table 6.7 Regression estimated weights of latent and measured variables

Category	Measured Component	Directional relationship	Latent component	Estimate	SE	CR	P
Supplier Side	ISSD	⟵	SRIP	0.39	0.051	7.643	***
	SRMI	⟵	ISSD	0.74	0.044	16.949	***
	SDDI	⟵	ISSD	0.3	0.091	3.325	***
	SDDI	⟵	SRMI	0.27	0.094	2.846	0.004
Manufacturer Side	ISSI	⟵	MISO	0.45	0.044	10.223	***
	LMAS	⟵	MISO	0.21	0.045	4.763	***
	LMAS	⟵	ISSI	0.3	0.066	4.631	***
	MPSS	⟵	LMAS	0.75	0.062	12.125	***
Manufacturer-supplier Side	OLWF	⟵	IUMS	0.65	0.106	6.155	***
	PBSA	⟵	OLWF	0.3	0.031	9.819	***
	PCMS	⟵	OLWF	0.49	0.04	12.251	***
	USRS	⟵	PBSA	0.38	0.081	4.688	***
	USRS	⟵	PCMS	0.27	0.057	4.651	***
External side	UIEA	⟵	UCSR	0.42	0.07	5.992	***
	UIEA	⟵	UURO	0.38	0.067	5.676	***
	UUSC	⟵	UIEA	0.33	0.086	3.868	***
	UUSC	⟵	UURO	0.25	0.093	2.631	0.009
	UUSC	⟵	UCSR	0.52	0.1	5.161	***
	RPMS	⟵	UUSC	0.91	0.068	13.374	***

Table 6.8 Correlation matrices of latent factors along with CRs and AVE

Category		SRMI	SRIP	SDDI	ISSD		CR	AVE
Supplier Side	SRMI	0.949					0.964	0.9
	SRIP	0.38	0.885				0.934	0.783
	SDDI	0.485	0.397	0.898			0.943	0.807
	ISSD	0.769	0.433	0.492	0.853		0.913	0.727
Manufacturer Side		ISSI	LMAS	MISO	MPSS		CR	AVE
	ISSI	0.849					0.911	0.721
	LMAS	0.53	0.914				0.938	0.836
	MISO	0.7	0.481	0.972			0.985	0.944
	MPSS	0.526	0.686	0.436	0.878		0.931	0.771
Manufacturer-supplier Side		USRS	OLWF	PCMS	IUMS	PBSA	CR	AVE
	USRS	0.87					0.925	0.757
	OLWF	0.443	0.976				0.988	0.953
	PCMS	0.506	0.628	0.889			0.938	0.79
	IUMS	0.234	0.343	0.379	0.913		0.952	0.833
	PBSA	0.51	0.538	0.588	0.393	0.888	0.937	0.789
External side		UCSR	UIEA	UUSC	RPMS	UURO	CR	AVE
	UCSR	0.885					0.916	0.784
	UIEA	0.481	0.941				0.958	0.885
	UUSC	0.515	0.495	0.874			0.928	0.764
	RPMS	0.471	0.4	0.727	0.95		0.966	0.903
	UURO	0.306	0.489	0.373	0.34	0.877	0.908	0.769

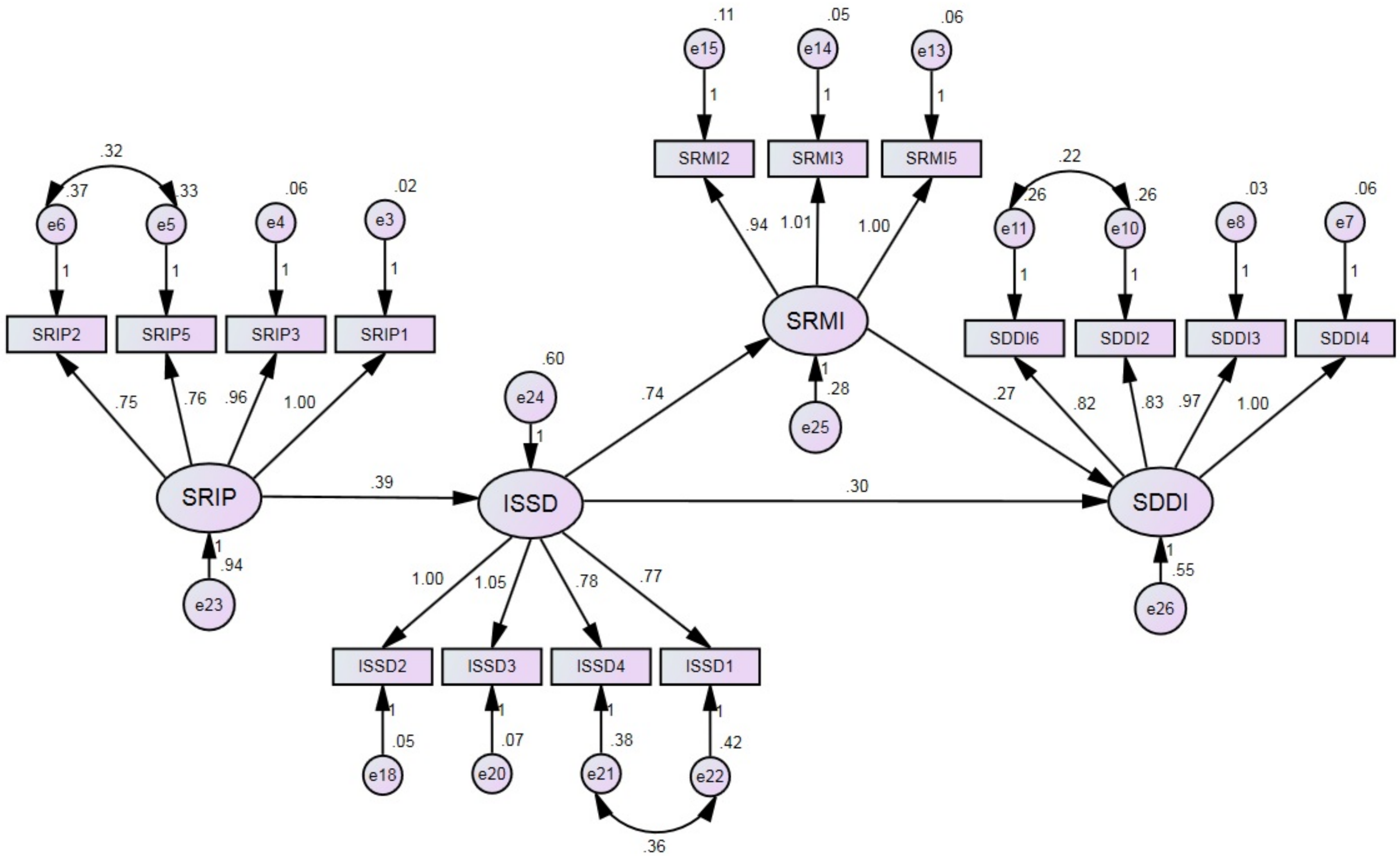


Figure 6.1 Path diagram validated to test the significance of impediments to SDPs from supplier side

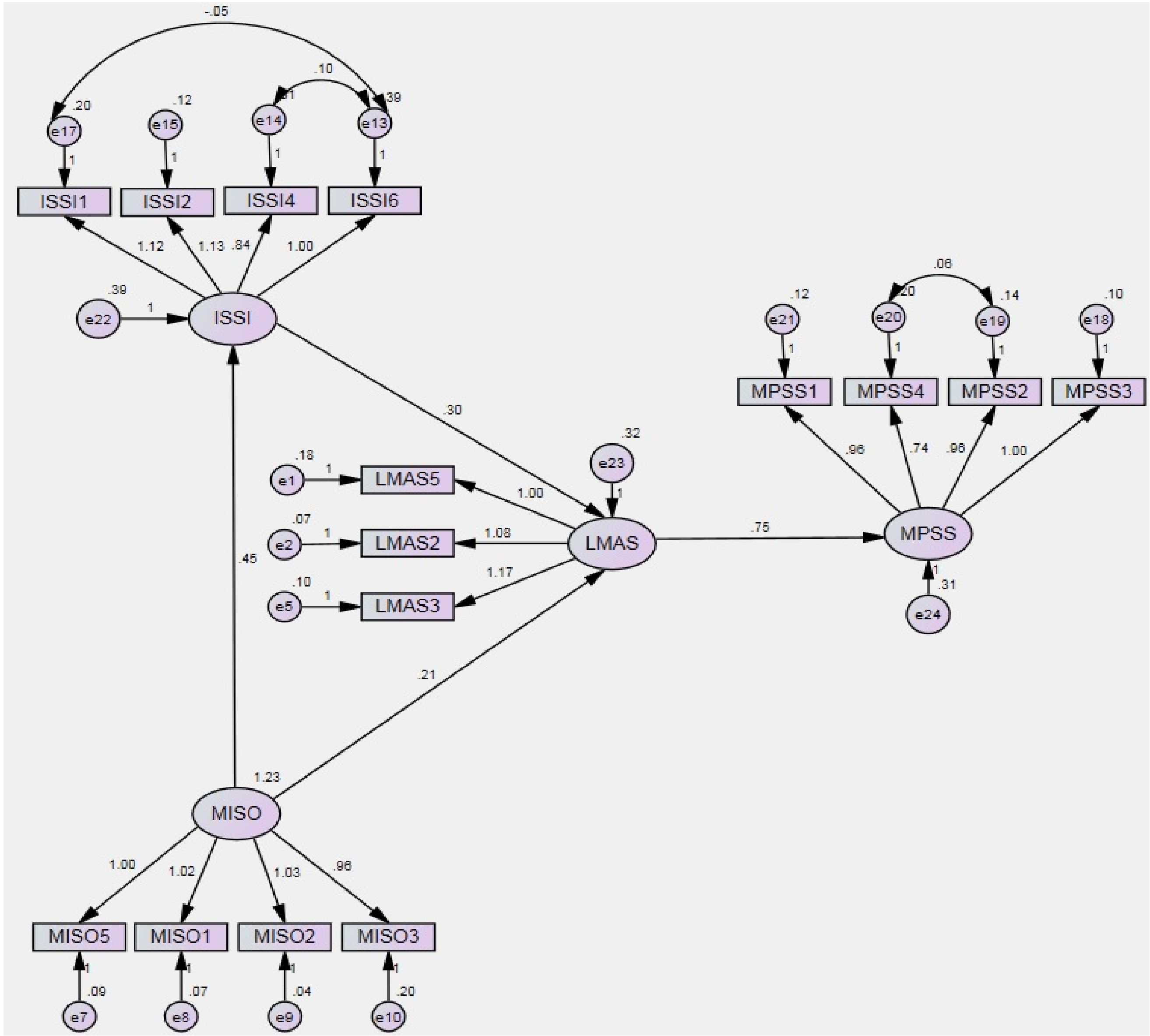


Figure 6.2 Path diagram validated to test the significance of impediments to SDPs from Manufacturer Side

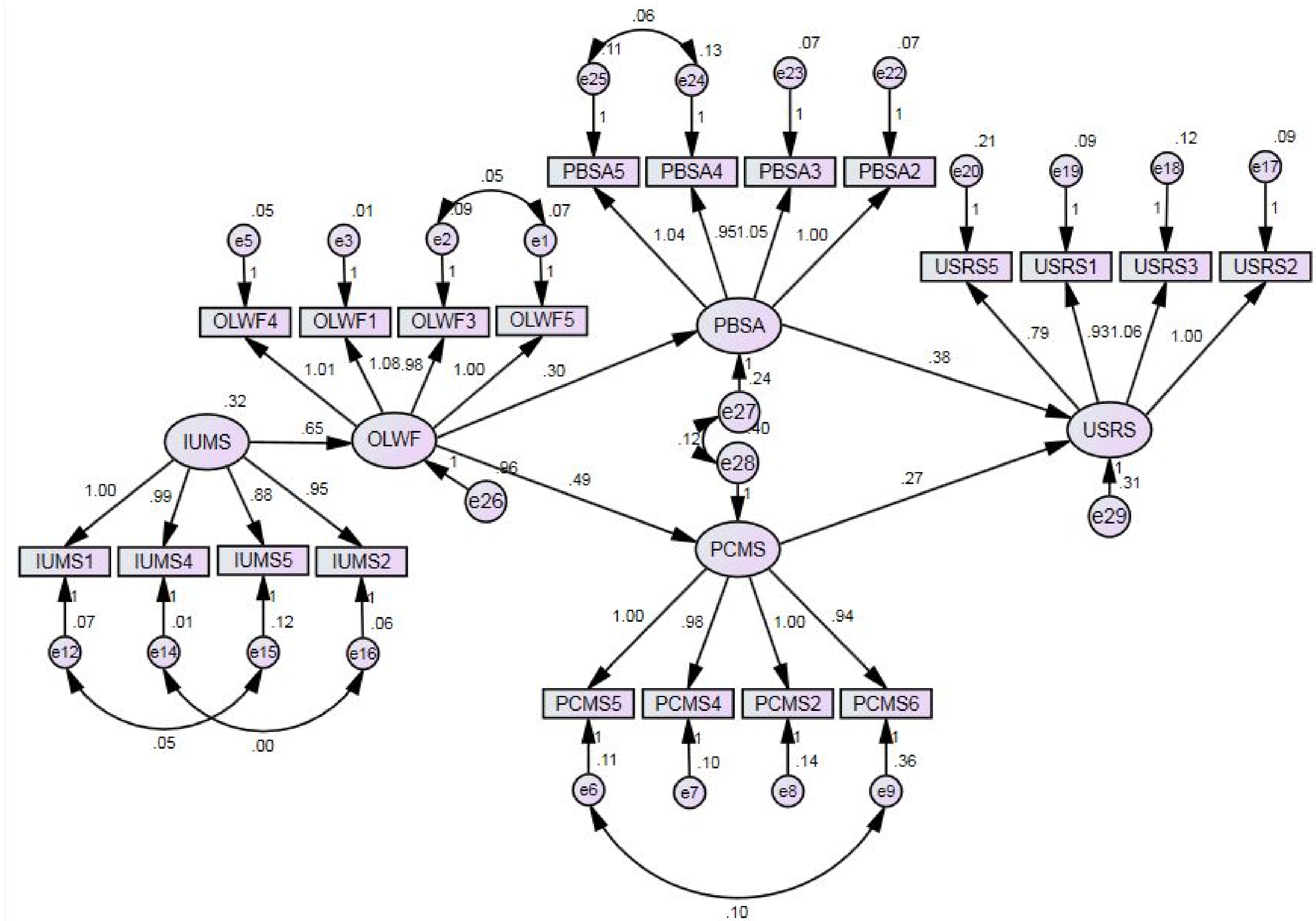


Figure 6.3 Path diagram validated to test the significance of impediments to SDPs from Manufacturer-supplier Side

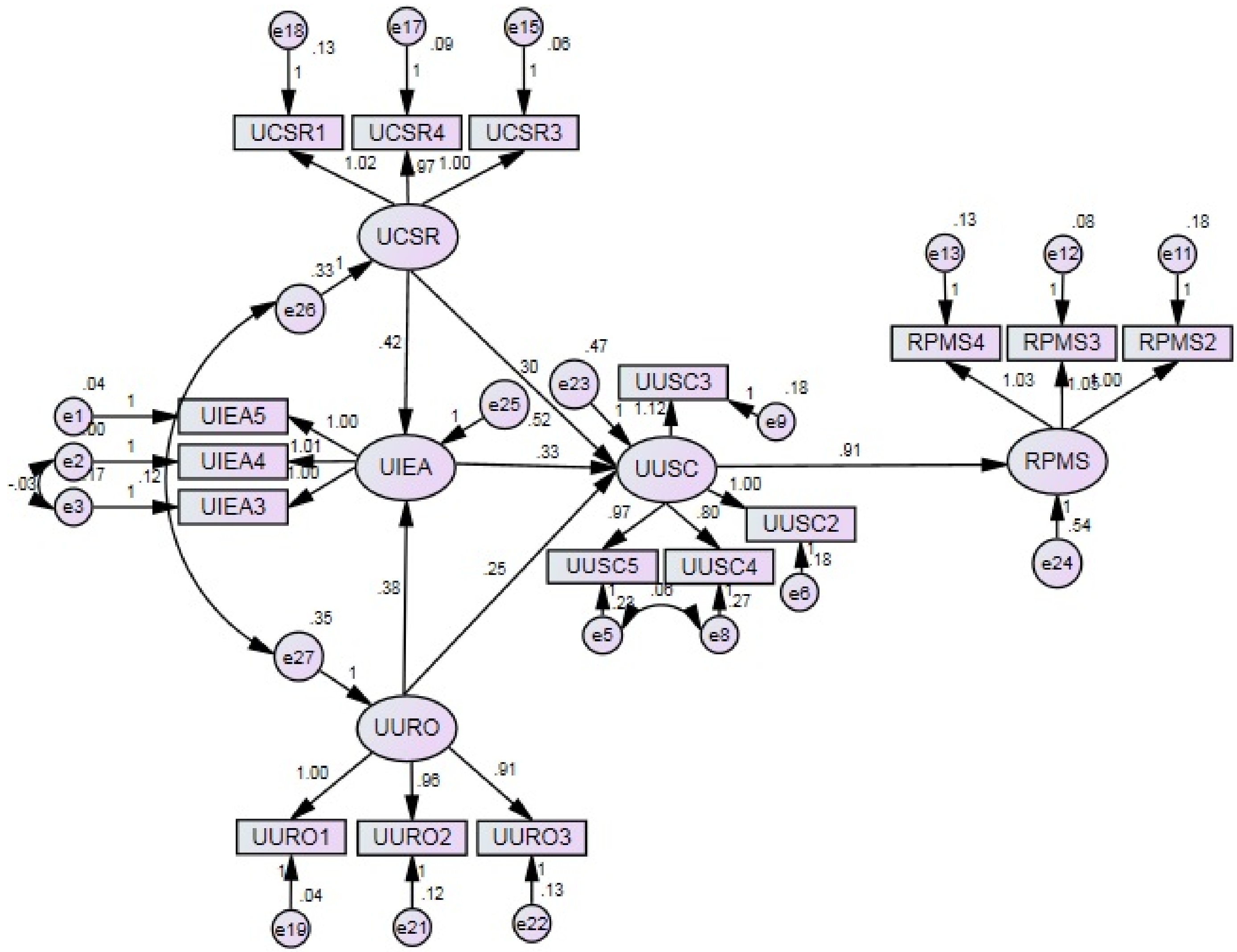


Figure 6.4 Path diagram validated to test the significance of impediments to SDPs from External Side

6.6 Results and discussions

The obtained p-values for path diagrams under respective categories were found to be significant. Thus, the estimated model in the path analysis was in conformance to the observed data (which indicates the null hypothesis) and so it was inferred that null hypotheses could not be rejected. The obtained results from the path analyses are categorically discussed in the following sub sections.

6.6.1 Interpretation of validated model under supplier side category

In this model, the significance of four hypotheses were tested (see Section 6.4.1). The estimates obtained along the hypothesized relationships in between the latent variables indicate that they are significant. Hence, it was decided that the proposed null hypotheses could not be rejected. Based on obtained path coefficients in between the latent variables, with reference to the hypothesis $H_{12,}$ it was found that the ill effect of a supplier’s supply and demand on a supplier increases the supplier's reluctance to manufacturer's initiatives. The path coefficient obtained along the hypothesized relationship was 0.74 which indicates that the tested relationship is highly significant. This is also confirmed from the experts’ feedback that often suppliers are affected because of supplier’s suppliers’ conditions. Moreover, the impact is so much that in practice the representatives from Original Equipment Manufacturers (OEMs) are often sent to audit supplier’s suppliers’ conditions (i.e. through Tier-1 to upstream suppliers) before signing the major contracts. On the other hand, non-involvement of a supplier is highly proportional to poor supplier commitment from demand perspective. So, most of the experts suggested that it is essential for a manufacturer to leverage orders among the suppliers in order to overcome this issue of supplier reluctance and also endeavor to achieve preferred buyer status so as to have long term benefits with the suppliers. From the path diagram, it can be seen that the said ISSD is effectuated by an SRIP (which is also an exogenous variable) as the test of significance in favor of hypothesis H_{11}

was proven to be significant. Here, an exogenous variable designates that it is independent in nature in the model and its variation may be significantly dependent on the variables external to the model under study. However, an exogenous variable can have a causal relationship and influence other variables in the model. Here the associated path coefficient for H_{11} was 0.39, which also indicates that the hypothesized relationship was significant and just next to H_{12} in terms of level of significance. The other two hypotheses H_{13} and H_{14} were also found to be significant in influencing the modeled variables under supplier side category.

6.6.2 Interpretation of validated model under manufacturer side category

The estimates obtained from the path analysis under this category revealed that all the hypotheses were significant. While among the path coefficients of the hypothesized relationships, the hypothesis H_{24} was found to be highly significant with a path coefficient of 0.75. In this regard, it was evident that the end effect i.e. manufacturer's poor supplier staking was highly influenced by the lack of manufacturer's affirmation to a supplier. In support to this, it was confirmed that the manufacturers have to experience deteriorating relationships with their suppliers and also lose potential relationship based advantages if there are no effective supporting approaches with systems perspective are devised and adopted in the supplier management practices. The systems perspective in this context denotes that a manufacturer is considerate about stakeholders' perspectives and accordingly devises its strategies without significantly jeopardizing their interests. Next, the hypothesis H_{24} was found to be highly significant with a path coefficient of 0.45. This indicates that a manufacturer's ineffective systems of operation (certainly an exogenous variable) in the model leads to improper supplier selection and SD initiatives. From experts' feedback, it was learnt that this is an important aspect prevailing with most of the manufacturers conducting SDPs. In practice many a time, it happens that manufacturers do not have systematic processes established in practice and this leads to extending incorrect priorities to the suppliers under SD and also ineffective SD initiatives are pursued. From path analysis, the other two hypotheses H_{23} and H_{22} were also found to be significant in influencing the paired latent variables respectively.

6.6.3 Interpretation of validated model under manufacturer-supplier side category

The estimated model through path analysis under this category shown that the hypothesis H_{31} was highly significant with a path coefficient of 0.65. In this hypothesis, the relationship significance of an exogenous variable IUMS in relation to OLWF was tested and it was found to be important among the impediments to SDPs under manufacturer-supplier side category. From experts' experience, it was learnt that if a manufacturer and supplier fails to promptly sense, comprehend and function according to the mutual interests, priorities and requirements the work force engaged in the supplier management find the processes daunting. It was expressed that most of the companies are misdirecting their workforce in carrying out the purchasing and supply management activities. This eventually led to the dearth of more experienced and skilled workforce in the purchasing arena. This OLWF is further related to PCMS in the hypothesis H_{33} and was obtained as the next significant relationship. It was learnt that, since the workforce are sought as communication points for the interactions in SD, the oppressed and limited workforce certainly led to poorly connected manufacturer-supplier manufacturing systems. It was found that due to OLWF there was no systematically directed efforts from the cross functional departments at manufacturer-supplier and thereby the effect of SD was diluted. Then, the hypothesis relating PBSA and USRS was also believed to be highly significant with a path coefficient value 0.38. This was supported by the experts and evinced that as buyer-supplier do not consciously align their efforts, objectives and preferences there will not be concurrence in the SD investments and apportioning the benefits.

6.6.4 Interpretation of validated model under external environment category

The variables modeled under this category essentially capture the salient specifics acting as impediments to SDPs from external environment. From the validated model, the hypothesis H_{46} was sought to be substantially significant in making the SDPs ineffective. It was having a very high path coefficient of 0.91. In favor of this, experts also equivocally commented that SDPs suffer from unpredictability and uncertainties in the supply chains, make the systems more prone to disruptions and eventually negate the positive effects of SD initiatives. So, it was inferred that there must be a process to timely measure and monitor the performance of SDPs, analyze the reasons behind declination in the performance and accordingly devise specific strategies to drive the performance. Next to H_{46}, the hypothesis H_{41} was highly significant with a path coefficient of 0.42. This was sustained because by pursuing the opportunities to unhealthy competition and in addition to the increased scarcity of resources, the unscrupulous internal agents instigated by external agents are induced to change the methodical course of actions. The chance for unscrupulous internal and external agents also to influence the variables of the model was strengthened by unusual and unstable regions of operation. This was evident as the tested hypothesis H_{42} was highly significant with a path coefficient of 0.38.

The abovementioned interpretations about the impediments to SDPs in Indian manufacturing environment would certainly assist the manufacturers to establish progressive systems for effective SDPs.

6.7 Sectional summary

The growing manufacturers' dependency on the suppliers and their supplier specific investments through SDPs call for assured returns from the suppliers. Despite the well-disposed manufacturers' intentions through SD initiatives, there are some impediments that dilute the favorable effects of SDPs. Thus in the current study, the impediments to SDPs in the context of Indian manufacturing industry were studied to establish a basis for a manufacturer to reduce the combined negative effects on SDPs. The impediments to SDPs excerpted from previous studies were categorically identified and then the principal components of impediments to SDPs were extracted by applying factor analysis. Further, the conceptual models were developed using these principal components and then the path analysis was applied to test the hypothesized relationships. Based on the statistically validated models under each category, certain useful insights were drawn for a manufacturer's assistance. Under supplier side category, it was found that a supplier's reluctance to its manufacturer's initiatives is highly influenced by the ill effects of the poor supplier's supply and demand management which in turn is highly influenced by the supplier resource incompetency (see the Figure 6.1). On a manufacturer's side category, it was found that a manufacturer's poor supplier staking was highly influenced by the lack of manufacturer's affirmation to a supplier and a manufacturer's ineffective systems of operation leads to improper supplier selection for development and SD initiatives (see Figure 6.2). Under manufacturer-supplier side category, it was found that insensitive and unreliable management systems at manufacturer-supplier leads to oppressed and limited work force. This in turn is leading to poorly connected manufacturing systems and also poor manufacturer-supplier alignment causes uncoordinated systems of resource sharing (see Figure 6.3). Finally, from external environment, it was found that the unpredictability and uncertainties in the supply chains make the manufacturing systems more risk prone. While unhealthy competition and scarcity of resources cause unscrupulous internal and external agents to intervene in the systematic execution of operations and this is further magnified by unusual and unstable regions of operation (see Figure 6.4). These observations about the impediments to SDPs under different categories must enable a manufacturer to efficaciously reduce the negative impact and eventually make its SDPs effective. Further, the statistically validated models can be used for studying a case situation of a specific company, explore the particular impediments to SDPs and eventually make the SDPs more resilient.

This ends the chapter 6 devoted for discussing the generic frameworks developed for addressing the impediments to SDPs. In the next chapter, the generic framework developed for cultivating the preferred supplier relationships has been discussed.

Chapter 7

Framework for Developing Preferred Supplier Relationships

7 Sectional abstract

Now-a-days, the manufacturers are exclusively discriminating among the critical and strategic suppliers for exploring the long standing competitive advantages. The manufacturers are increasingly inclined to have a preferred supply base established which is capable of competitively supporting in meeting their customers' requirements. While the suppliers are given strategic roles to play in the value addition process, in the current dynamic and complex business environments hardly there is any framework for the manufacturers to proactively build preferred supplier relationships viz. in the manufacturing setup of a developing country. So, the current study is aimed at examining the essential and necessary aspects the manufacturers have to focus to have preferred supplier relationships developed in a supply base. In this regard, several Preferred Supplier Enablers (PSEs) that efficaciously assist a manufacturer in developing the preferred supplier relationships were identified. On the basis of these PSEs, a survey questionnaire was developed and the response data was collected by administering it to the experts drawn from Indian manufacturing industry. Subsequently, the directed relationships in between the principal components extracted for the PSEs were analyzed and a generic structural framework was developed. The structural framework was then utilized in the application of graph theoretic approach which provides a manufacturer to assess the extent to which the preferred supplier relationships can be developed.

7.1 Necessity for a framework for cultivating preferred supplier relationships

In the current competitive manufacturing environments, the manufacturers have to concentrate and improve their supplier relationships along with the customer relationship management (Ulaga and Eggert, 2006). Previously, demand management was more stressed in comparison to supply management and so, the suppliers were not given much importance and were often perceived as burden of costs. But, as the equations of suppliers' bargaining powers along the supply chains are changed, now the manufacturers have to rely on their important and potential suppliers so as to survive in the supply chain competition. In modernizing the procurement systems, the concept of extending the preferred supplier relationships through preferred supplier programs is one of the important strategies and also often implicitly adopted by the manufacturers (Neven et al., 2009). Primarily, the concept of establishing preferred supplier relationships is aimed at for a number of reasons, mainly to establish long term relationships with the key suppliers (Walter et al., 2003); to have secure supply base by reducing the suppliers' risks due to opportunistic behavior (Gosling et al., 2010a); have special contractual agreements with the suppliers (Sieweke et al., 2012); to go beyond the price structures offered by the suppliers and incorporate total cost perspective (Stjernström and Bengtsson, 2004); to safely direct their future investments (Van Everdingen et al., 2000); and to have few number of reliable suppliers in the supply base and thereby subdue the tremendous cost pressures (Galt and Dale, 1991; Dorsch et al., 1998; and Walter et al., 2003). Characteristically, manufacturers have to attribute preferred supplier status to their key and potential suppliers due to growing percentage of outsourcing and in turn increased dependency on the suppliers with a view to focus more on the their core competencies. Extending preferred supplier status is considered as a means by the manufacturers to recognize, differentiate and acknowledge the capable suppliers' contributions so as to sustain and improve cooperative relationships in the long run (Bhattachrya et al., 1995; and Dorsch et al., 1998). On the other hand, from suppliers' perspective, the preferred supplier status is also much sought by the suppliers as they relatively receive more volumes of business, assured future business, relational commitment and more priority in comparison to the other suppliers (Feldman, 1998). Moreover, the suppliers must aspire and prepare to become distinctive from other suppliers so as to become preferred supplier for the focal manufacturers (Quayle, 2000; and Ulaga and Eggert, 2006). Thus, from both manufacturers' and suppliers' perspectives, the concept of preferred supplier has been a matter of interest. Having said about the motives for establishing preferred supplier relationships and the pursuit of preferred supplier status from both manufacturers' and suppliers' perspectives, there must be a pragmatic approach for ameliorating the practice of preferred supplier concept. Hence, in this section the focus is on examining the considerations that a manufacturer must pursue in cultivating preferred supplier relationships. In this regard, several Preferred Supplier Enablers (PSEs) that efficaciously assist a manufacturer in cultivating the preferred supplier relationships were identified. On the basis of these PSEs, a survey questionnaire was developed and the response data was collected by administering it to the experts drawn from Indian manufacturing industry. The obtained response data was analyzed by using an SPSS 20 software package and the principal components for PSEs were extracted through factor analysis. Subsequently, the directed relationships in between the principal components were analyzed and a generic structural framework was developed using an AMOS 20 software package. The obtained structural framework was then utilized in the application of graph theoretic approach which further provides a manufacturer to assess the extent to which the preferred supplier relationships can be developed. Since, for most of the global supply chains, the suppliers are from the developing countries, the current study in the context of Indian manufacturing environment would be an important contribution for both in research and practice. The next section connects to the previous studies that highlighted the effect of PSEs in having the preferred supplier relationships established.

7.2 Literature review in support of conceptual model development

In this section, the literature support that assists a manufacturer in extending preferred supplier relationships are extracted. The excerptions from the literature may also help a supplier aspiring for preferred supplier status to accordingly gear up. The growing emphasis on the sustainable manufacturing practices among the manufacturers is calling for suppliers' having sustainable systems, products and processes used in the manufacturing. It was Starbucks which introduced preferred supplier program to develop and accordingly reward their suppliers with future business opportunities to achieve overall sustainable development (Lee, 2008). With the growing emphasis on sustainable manufacturing, the manufacturers are also actively partnering with the suppliers who are responsible and are also at par in meeting the economic, societal and environmental performance requirements (Lee et al., 2009). In this regard, suppliers are also evaluated along the sustainability factors so as to select the preferred suppliers with green capabilities (Bai et al., 2010). In maintaining the suppliers, the manufacturers are also transferring the onus on to the suppliers to bear the compliance responsibility with regards to fulfilling the certification standards and requirements (Neilson and Pritchard, 2007). Through these, the manufacturers are inherently considering to partner with the suppliers who are relatively at ease in providing the supplies with less discrepancies (Routroy and Kumar, 2015). Besides, since the supplier’s supplies, services and practices also substantially influence and urge the manufacturers’ end customers’ satisfaction, suppliers’ brand name and positive feedback in the industry are also used for marketing (Christopher, 1996). Having said about the chances for the suppliers’ with suitable manufacturing systems to achieve preferred supplier status, the other depending constructs are to be explored.

Walter et al. (2003) specified that a supplier dedicating certain resource investments in the relationship development attract manufacturers' stance and in reciprocation make the manufacturers to develop the suppliers for meeting their long term requirements. Due to this, in turn the suppliers also operate through proactive manufacturing systems and as a result the partnered manufacturers will have better development in the utilization of the resources (Kumar and Routroy, 2015). Suppliers also will have to be aptly integrated with the manufacturers and in turn will be able to cooperate, coordinate and collaborate in accordance to the proposed initiatives and strategically align themselves to meet manufacturers' specific functional requirements (Lockstroem et al., 2010; Le Dain et al., 2011; and Ralston et al., 2015). Due to this integration, suppliers will also inherently share responsibility for their supplies and services without manufacturers needfully levying on them (Closs and Mollenkopf, 2004; and Lockstroem et al., 2010). Suppliers become well aware of manufacturer's business plans, actions, goals and objectives which in turn meet the manufacturer's requirements (Saenz et al., 2014). Moreover, the essential flexibility can be built by the suppliers to support product and process design changes, demand fluctuations and also to align with the manufacturer's compressed product life cycles (Kumar and Routroy, 2015). At this juncture, it can be drawn that suppliers with suitable or compatible manufacturing systems can enable them to strategically align with the manufacturers (Saenz et al., 2014).

Suppliers in extending preferential support to a manufacturer prominently base their satisfaction and manufacturers' attraction in view of deriving strategic benefits from their manufacturing customers (Schiele et al., 2012; Hüttinger et al., 2012; and Tóth et al., 2015). Since, a favorably dispositioned supplier allocates a manufacturer the best of the resources and supplies, manufacturers are inclined to associate with the suppliers ascribing Preferred Customer Status

(PCS) and aspire for PCS with it key suppliers (Nollet et al., 2012; and Kumar and Routroy, 2016). Supplier treating a manufacturer as a preferred customer will have responsive turnout to its calls and offers favorable supplies and services to the manufacturer (Nollet et al., 2012). Moreover, suppliers with preferred customer perspective will responsively assist a manufacturer in adopting and adapting to the changing manufacturing industry trends, methods, technologies and standards (Lai et al., 2012). Apart from suppliers' responsiveness, manufacturers are also looking for the suppliers capable of effectively innovating and willing to preferentially transfer the advantages (i.e. cost saving opportunities as well as improving manufacturers' competitive position) (Ellis et al., 2012 and Schiele et al., 2011). Manufacturers expect substantial reduction in the transaction and execution costs with the favorably dispositioned suppliers (Sieweke et al., 2012; and Ellis et al., 2012). With regards to the relationship development, a manufacturer can envision evolution of manufacturer-supplier relationship over a period of time with clear understanding of mutual requirements (Bemelmans et al., 2015). As a result, much of the conflict resolution mechanisms contrived to handle in the buyer-supplier transactions are best affected through mutual trust and for fulfilling mutual interests (Routroy and Sunil Kumar, 2014; and AlMaian et al., 2015).

In developing the preferred supplier systems, a manufacturer would certainly call for suppliers to perform beyond the basic requirements and achieve higher performance standards (Ruben et al., 2007). The preferred suppliers are expected to become qualitatively and quantitatively significant in terms of value generated for the manufacturers as there has been a shift in the emphasis from price to total cost perspective (Ulaga and Eggert, 2006; and Sieweke et al., 2012). However, Nagle and Cressman (2002) mentioned that often buyers lack thorough understanding of qualitative and quantitative significance in awarding the preferences to the suppliers. The manufacturers prominently expect that pricing structure quoted by a supplier must be sensible and consistent and must be considerate about the profit and loss incurred because of its supplies and the situations prevailing at the manufacturers. While, suppliers mainly expect that the manufacturer must consider suppliers' pricing in terms of value added as they become sources of profit improvement for the suppliers (Nagle and Cressman, 2002). Along with the aspects of consistent pricing and total cost perspective, the preferred suppliers are expected to timely offer the supplies and services with better availability as and when required by the manufacturer. In other words, the suppliers must pose relatively less risks and uncertainties to the manufacturers (Gosling et al., 2010b). With regards to the serious scandals (such as horse meat scandal) (Bernzen, 2014), even in the manufacturing industry concerns about the suppliers' ethical standards and operations with respect to the policies and interests of the manufacturer are growing. Suppliers' are expected to be relatively more transparent and amicable to the manufacturer's requirements. However, onus is also on the manufacturers to understand the capacity of its suppliers and know the details of sub-contracted suppliers to avoid the scandals and unfortunate incidents (with reference to KPMG (2014)). Overall, indirectly a manufacturer's level of satisfaction with the suppliers' supplies inherently cultivates the preferred supplier relationships. Thus, in perceiving a supplier as a preferred partner basically a manufacturer would look for a supplier compatible with the manufacturer, who is capable of supporting, and also has willingness to award preference to the manufacturer.

After ensuring certain preliminaries in extending the preferred supplier relationships, the manufacturers look for suppliers' potential for establishing progressive environment for the manufacturer. Certainly, a manufacturer looks for a supplier who is effective and efficient in adopting and adapting to the manufacturer's essential change management and improvement strategies (Miyamoto and Rexha, 2004). Since the suppliers' contributions are also deciding the manufacturing supply chains' ability to compete, the emphasis on the suppliers' capability to develop innovative and competitive featured supplies and services is growing (Azadegan, 2008). Suppliers are expected to have visionary and committed top management who can properly steer the investments in the capacity development (Quayle, 2000). Manufacturers are ascertain about strength of suppliers' organizational structure, ability as well as learning systems to competitively put through the manufacturer's requirements (Arroyo-López et al., 2012). This is essential because, most of the manufacturers are concerned about the ease to transfer essential resources for development and so, follow-up the returns on their investments (Grimm et al., 2014; and Routroy and Kumar, 2015). In this respect, even the suppliers' accessibility to the manufacturer is called into the question viz. in terms how good the communication, feedback and learning systems established with the suppliers (Routroy and Kumar, 2015; and AlMaian et al., 2015). Further, in the current dynamic business environments, a supplier's resilience and capability to mitigate the supply chain uncertainties and disruptions and despite these its effectiveness to support the manufacturer are also sought (Yilmaz-Börekçi et al., 2015). Finally, a preferred supplier is expected to take the responsibility for entire supply chain and support for overall supply chain development (Hingley et al., 2015).

The abovementioned excerpts from the literature certainly evokes the inquisition to find out the essential directions to focus in developing the preferred supplier relationships. On the basis of this literature review, in the later sections certain hypotheses will be formulated to test the directed relationships between the prominent aspects in cultivating the preferred supplier relationships.

7.3 Research methodology

The purpose of this study is to establish a directional framework for a manufacturer's assistance in cultivating the preferred supplier relationships with its key suppliers. Further, to provide a basis for a manufacturer to determine the extent to which the preferred supplier relationships can be cultivated with the suppliers. In this regard, the research methodology followed in the study mainly comprised of three phases i.e., extracting the principal components for cultivating the preferred supplier relationships, testing the directed relationships between the principal components using path analysis and an application of graph theory to determine the extents to which the preferred supplier relationships can be developed.

7.3.1 Extraction of principal components for cultivating preferred supplier relationships

In this a study, a survey questionnaire was developed (see Appendix) along the significant aspects a manufacturer has to focus in developing the preferred supplier relationships with its key suppliers. The questionnaire developed was on the basis of extensive literature review with regards to the preferred supplier concept, brain storming sessions and discussions held with the academic and industry experts in India. Before finalizing the questionnaire, a pilot study was conducted by drawing a small group of industry experts from Indian manufacturing environment. On the basis of experts' opinions, the content and length of the questionnaire were refined, so that the responses were collected at ease. In refining the questionnaire, the redundant, irrelevant and unreadable questions were carefully eliminated. The refined questionnaire was then administered to a sample of industry experts to collect their opinions on a Likert scale of 1 to 5 where 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree and 5: Strongly Agree. The data collection was carried out mainly through personal interviews (during several industrial visits). The companies that were personally visited for conducting the interviews were mainly located in the southern and northern parts of India. Further, by accessing the contact details of the companies from the databases of Confederation of Indian Industries (CII) and Gujarat Industrial Development Corporation (GIDC) the industry experts were contacted. These interactions were mainly through telephonic conversations, internet audio calls, web meetings, emails, shared online spread sheets and by posting the hard copies of the questionnaire. Authors could also meet and interact with the industry experts during several international conferences, industrial summits, workshops and exhibitions. The sample of experts consulted in conducting the current study were mostly designated as chief purchasing officers, procurement and supply heads, general managers, assistant general managers, senior managers, supplier quality engineers, senior engineering managers, SD officers (or) engineers (or) managers. The percentage distribution of the experts (i.e. in the consulted sample of experts) with respect to their designations and the industry are shown in the Table 7.1 and Table 7.2 respectively. The consulted experts in this study were having more than eight years of experience in the industry and were all professionally qualified with degrees in engineering and business administration. Totally, around 1560 number of experts were requested to express their opinions, but out of which 436 responses were obtained. Further, after cleaning the data (using statistical software SPSS 20) 398 responses were found to be useful with an overall response rate of 25.51%. Since, the number of questions asked (also called as observed variables) were 37, the sample of responses obtained was considered to be sufficient as it was ten times the number of observed variables. Then, the factor analysis was applied in order to reduce the observed variables to fewer principal dimensions. But, before applying the factor analysis on the collected data, the essential tests that decide the viability in the application of factor analysis were carried out. The tests performed were on the basis of Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett’s test of sphericity and an anti-image correlation matrix. The results obtained from KMO and Bartlett’s tests are shown in the Table 7.3. These results indicate the presence of high degree of correlation between the observed variables, as the KMO measure obtained was 0.845 which should be at least 0.5 and the obtained P-value under Bartlett’s test of sphericity also shown that it was significant. The anti-image correlation matrix obtained was also supporting the application of factor analysis as it was having negative partial correlations with its diagonal elements all greater than 0.5 while the lowest among the diagonal elements was 0.692 (> 0.5). Since, all the performed tests were clearly indicating the presence of underlying dimensions to extract, the factor analysis was applied to extract the principal components for PSEs.

Table 7.1 Levels of respondents participated in the study

Level	Frequency	Percentage
Engineer/ Assistant Manager level	131	33
Senior Engineer/ Manager level	154	38
General Manager /Chief Engineer level	78	20
Purchasing and supply heads and above	35	9
Total	398	100

Table 7.2 Industry wise frequencies of the respondents participated in the study

Company Type	Industry Group	Frequency	Percentage (%)
Automotive	1	79	20
Electronics	2	48	12
Aerospace	3	48	12
Industrial equipment	4	49	12
Energy equipment manufacturing	5	40	10
Non-durable consumer products	6	36	9
Materials and Construction	7	35	9
Pharmaceuticals and biotechnology	8	24	6
Food, Beverage	9	21	5
Metals and Mining	10	18	5
Total		398	100.0

Table 7.3 Kaiser-Meyer-Olkin and Bartlett's test results

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.853
Bartlett's Test of Sphericity	Approx. Chi-Square	15021.557
	Df	666
	Sig.	.000

7.3.1.1 Exploratory Factor Analysis

In conducting the factor analysis, the Exploratory Factor Analysis (EFA) was initially applied to reduce the dimensions by exploring the underlying pattern in the data. Through an EFA the observed variables were grouped (on the basis of their correlations) into smaller set of dimensions called as principal components or factors. In carrying out this dimension reduction, the Principal Component Analysis (PCA) as an extraction method and Varimax as a method of rotation were applied using SPSS 20. These principal components were extracted according to the Kaiser Criterion by setting the Eigen value equal to ‘1’. By applying the EFA, totally five principal components were extracted with a 73.372 % maximum variance explained (see Table 7.4). These principal components or latent variables were suitably named as Supplier’s Response to Manufacturer's Requirements (SRMR), Supplier’s Compatible Manufacturing Systems (SCMS), Supplier's Potential for Manufacturer's Furtherance (SPMF), Supplier's Preferential Support to a Manufacturer (SPSM) and Supplier Strategic Alignment with the Manufacturer (SSAM) on the basis of observed variables grouped under the latent variable. The Scree plot from SPSS output also shows the extraction of five components with respect to the contribution of each component in explaining the portion of total variance (expressed in terms Eigen values) as shown in the Figure 7.1. The SPSS output also provides the communalities of all observed variables which indicate their relevance in accounting the variance explained by latent variables. The variables namely SMPF5 and SMPF6 were eliminated as they were less than 0.5. Further, the rotated component matrix in the SPSS output gave out the correlations between the observed variables and the components extracted in the form of factor loadings. The row-wise sum of the squares of these factor loadings would give the communalities (i.e. variance explained by the observed variables) of the observed variables and the column-sum of the squares of factor loadings would give the

Eigen values (i.e. variance explained by the components/ latent variables) (Janssens et al., 2008). In this study the factor loadings greater than 0.5 were considered to be significant enough and also the precaution was taken that no variable is having cross loading more than 0.4 with other components. The obtained factor loadings for the variables grouped under the respective components are shown in the Table 7.5. Further, the reliability analysis was conducted in order to verify the consistency in the obtained results viz. the accountability of the variables in defining the latent variables. In the reliability analysis, the Chronbach's alpha value was determined for each latent variable. It was noted that obtained alpha values were more than permissible value i.e. 0.70. The obtained Chronbach's alpha estimates for the five principal components were SRMR - 0.956, SCMS - 0.936, SMPF – 0.890, SPSM - 0.898, SSAM - 0.937. After confirming that the grouped observed variables consistently define their respective latent variables the configurations were considered for further analyses.

Table 7.4 Total variance explained by the extracted components

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.981	34.317	34.317	10.981	34.317	34.317	6.051	18.911	18.911
2	4.676	14.613	48.930	4.676	14.613	48.930	5.677	17.740	36.651
3	3.242	10.131	59.060	3.242	10.131	59.060	4.560	14.250	50.901
4	2.630	8.220	67.281	2.630	8.220	67.281	3.611	11.286	62.186
5	1.949	6.091	73.372	1.949	6.091	73.372	3.579	11.186	73.372
Extraction Method: Principal Component Analysis.									

Table 7.5 Rotated component matrix obtained from factor analysis

Observed Variable	Component				
	1	2	3	4	5
SRMR3	.880	.153	.210	.112	.187
SRMR7	.864	.117	.160	.062	.140
SRMR6	.861	.131	.228	.101	.163
SRMR2	.826	.172	.202	.143	.091
SRMR1	.790	.195	.203	.146	.106
SRMR5	.787	.156	.183	.109	.232
SRMR8	.786	.187	.214	.118	.123
SRMR4	.731	.163	.145	.070	.199
SSAM3	.111	.879	.123	.099	-.054
SSAM5	.063	.877	.095	.073	-.003
SSAM8	.124	.831	.106	.104	-.036
SSAM2	.104	.830	.065	.153	-.049
SSAM6	.148	.826	.135	.038	.010
SSAM4	.102	.817	.078	-.028	.078
SSAM7	.226	.737	-.008	.061	-.026
SSAM1	.232	.711	.050	.140	-.042
SCMS2	.209	.067	.849	.194	.072
SCMS3	.247	.117	.841	.170	-.035
SCMS5	.175	.061	.838	.209	.088
SCMS4	.163	.059	.814	.132	.111
SCMS1	.235	.160	.786	.139	.042
SCMS6	.300	.159	.781	.132	.042
SPSM3	.129	.142	.166	.872	.012
SPSM8	.161	.151	.139	.865	.013
SPSM5	.071	.046	.123	.801	.153
SPSM2	.114	.118	.233	.771	.086
SPSM4	.135	.076	.189	.702	.158
SMPF7	.209	-.045	.005	.064	.876
SMPF4	.131	.017	.035	.047	.839
SMPF3	.166	-.066	.109	.072	.821
SMPF1	.197	-.037	.046	.137	.758
SMPF2	.142	.003	.064	.076	.740

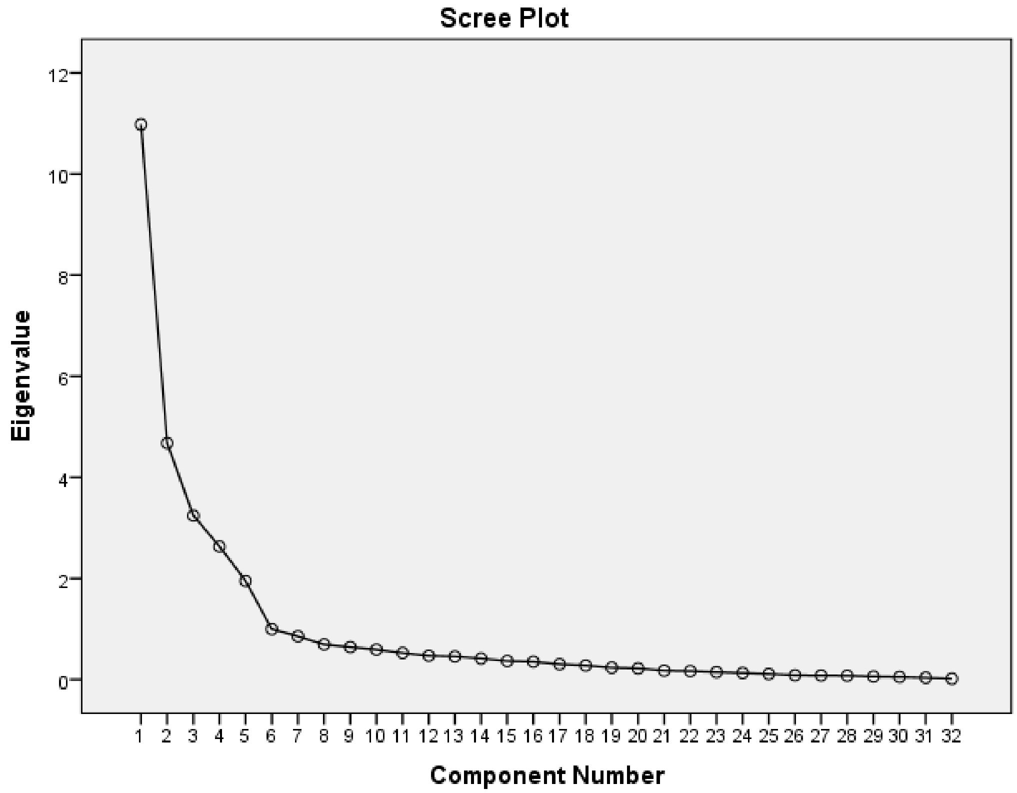


Figure 7.1 Scree plot showing the principal components extracted

7.3.1.2 Confirmatory Factor Analysis

The obtained configurations of observed and latent variables from EFA were used in conducting the Confirmatory Factor Analysis (CFA). In the CFA, the predictability of the observed variables under their respective latent variables were estimated. The analysis was started by modeling the relationships between all the latent variables as a path diagram in AMOS 20. The model was having 37 observed variables and five latent variables. After calculating the estimates, the initial model specifications obtained were $\chi^2 = 3874.390$, df = 454, $\chi^2/df = 8.534$, GFI = 0.654, AGFI = .598, RMSEA = 0.138, CFI = 0.751, RMR = 0.0702. As the initial model specifications were not at par in comparison with the permissible limits (Table 7.6) the model was refined. The model refinement was carried out according to Wang and Ahmed (2004) till the model fit indices are in conformance to the permissible limits. Janssens et al. (2008) also mentioned that in refining the model, the standardized residual covariances matrix has to be checked and then it was ensured that no correlation was greater than |2.58|. Then in the analysis properties of AMOS, the threshold value for the modification indices was set to ‘4’ and subsequently, the estimates were calculated. On the basis of the suggested modification indices, the refinement of the model was carried out repetitively till the model specifications are at par with the acceptable limits. The model specifications after refining the model were χ^2 = 387.987, df = 158, χ^2/df = 2.456, GFI = .914, AGFI = 0.885, RMSEA = .060, CFI = .959, SRMR = .0545. Since the model specifications for the refined model were at par with the permissible limits and hence, the model was considered to be fit to make measurements. The fitted model was subjected to the tests namely, unidimensionality (Janssens et al., 2008), convergent validity (Anderson and Gerbing, 1988), reliability (Gaskin, 2012) and discriminant validity (Hair et al., 2006) for making the authentic dimensions. The unidimensionality test was performed to ascertain the ability of the observed variables in defining the latent variables. In performing the unidimensionality test, the critical ratios for the relationships between the observed and latent variables were ensured to be greater than 1.96. Since, the lowest of the critical ratios was 12.508 the measurement model was considered to have fulfilled the unidimensionality test. Then the model was subjected to convergent validity test by examining the standard regression coefficients estimated for the relationships between the observed and latent variables to be more than 0.5 (Janssens et al., 2008). Since the lowest among the standard regression weights was 0.551, the model was considered to have satisfied the convergent validity. According to Gaskin (2012), the composite reliabilities estimated for all the latent variables must be more than 0.7 so as to fulfill the reliability test. The composite reliabilities estimated for the latent variables were SPSM – 0.881, SRMR – 0.891, SSAM – 0.876, SCMS – 0.907 and SMPF –

0.867 where all were greater than 0.7 fulfilling the conditions for reliability. Finally, according to Gaskin (2012) the discriminant validity test was performed by examining square root of Average Variance Explained (AVE) placed along the diagonal of a factor correlation matrix must be greater than the correlations between the factors. It can be seen from Table 7.7 that the square root of AVE by the latent factors are greater than the correlations. Since the model was satisfying all the conditions of unidimensionality, convergent validity, reliability and discriminant validity, it was believed that the measurement model was good enough to make estimates.

Table 7.6 Permissible limits of model fit indices for an acceptable quality model

Model parameters	SM integration	Permissible range	Citation
$\chi 2$/df	1.163	≤3	Hu and Bentler (1999); Steiger (1990); Byrne (2013)
GFI	0.998	≥0.90	Mulaik et al. (1989)
AGFI	0.971	≥0.80	Bentler (1990); Hu and Bentler (1999)
RMSEA	0.026	≤0.10	Browne and Cudeck (1992)
CFI	0.999	≥0.90	McDonald and Marsh (1990)
RMR	0.087	≤0.14	Steiger (1990); Byrne (2013)

Table 7.7 Reliability and validity test results of latent variables

Latent Variable	CR	AVE	MSV	ASV	SPSM	SRMR	SSAM	SCMS	SMPF
SPSM	0.881	0.662	0.144	0.084	0.814				
SRMR	0.891	0.674	0.271	0.156	0.318	0.821			
SSAM	0.876	0.640	0.162	0.082	0.284	0.402	0.800		
SCMS	0.907	0.711	0.271	0.128	0.379	0.521	0.288	0.843	
SMPF	0.867	0.631	0.089	0.029	0.103	0.299	-0.034	0.115	0.794

7.3.2 Hypothetical testing of the directed relationships using path analysis

In this section, the measurement model validated through CFA is used for testing the conceptually laid causal relationships between the latent variables. The conceptual model was developed on the basis of literature support presented in the Section 7.2, brainstorming sessions and discussions held with the academic and industry experts. Further, the conceptual model was constructed as a path diagram in AMOS 20 to test the significance of the relationships and estimate the relationships between the latent variables using structural equation model/ path analysis. Totally, there were seven hypotheses formulated in testing the conceptual model. The hypotheses tested are mentioned below,

- *H_1: Supplier's compatible manufacturing system positively enables the supplier to extend preferential support to a manufacturer.*
- *H_2: Supplier's compatible manufacturing system positively influences the supplier to conform its response to a manufacturer's requirements.*
- *H_3: Supplier's compatible manufacturing system positively leads to strategic alignment between supplier and manufacturer.*
- *H_4: Supplier's preferential support extended to a manufacturer positively makes the supplier conform its response to the manufacturer's requirements.*
- *H_5: Strategic alignment between supplier and manufacturer positively improves the supplier's response to the manufacturer's requirements.*
- *H_6: Strategic alignment between a supplier and a manufacturer positively influences the supplier to extend preferential support to the manufacturer.*
- *H_7: Supplier's response to a manufacturer's requirements offers the necessary potential for the manufacturer's furtherance.*

In testing the significance and estimating the relationships between the latent variables, the previously collected data along the observed variables was used. It was ensured that the estimated model was also fit with a P-value < 0.05 i.e. the estimated and sample covariance matrices are not significantly different. In other words, the estimated model nearly represent the experts' opinions about possible relationships between the latent variables. After calculating the estimates in AMOS 20, it was found that all the tested relationships were significant (see Table 7.8). The quality of the model was also acceptable as all the specifications were satisfying the permissible limits. The obtained model specifications were $\chi^2 = 414.420$, df = 161, $\chi^2/df = 2.574$, GFI = 0.908, AGFI = 0.880, RMSEA = .060, CFI = .953, SRMR = .0595. Thus, this statistically validated model can be used as a structural framework by the manufacturers for efficaciously cultivating the preferred supplier relationships with their key suppliers. The calculated estimates along the tested hypothesized relationships between the latent variables are shown in the Figure 7.2.

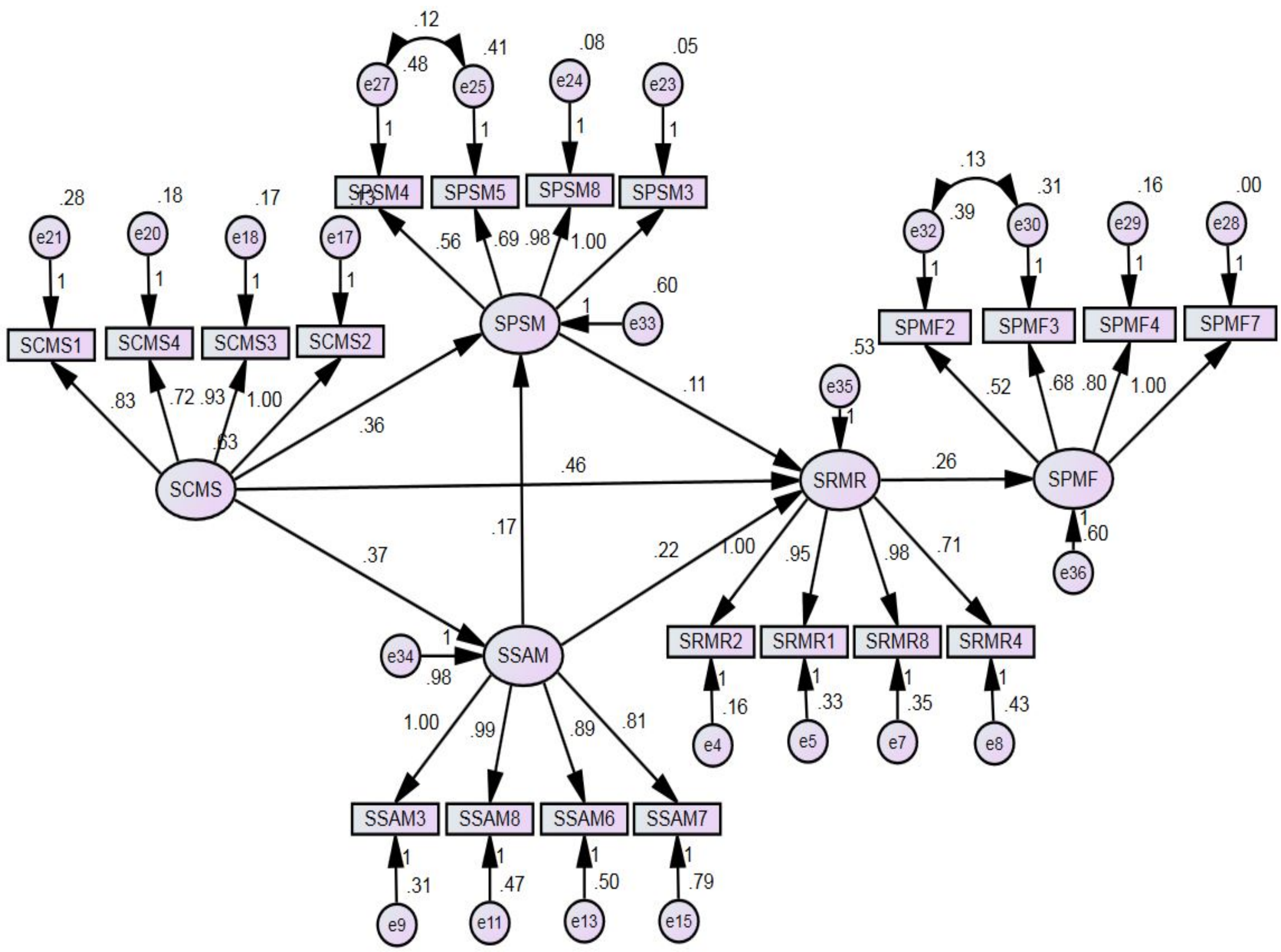


Figure 7.2 Calculated estimates of hypothesized relationships through path analysis

Table 7.8 Regression estimated weights of hypothetically related latent variables

Latent Variable	Directional relationship	Latent Variable	Estimate	S.E.	C.R.	P
SSAM	⟵	SCMS	0.375	0.071	5.292	***
SPSM	⟵	SSAM	0.167	0.044	3.835	***
SPSM	⟵	SCMS	0.361	0.056	6.418	***
SRMR	⟵	SSAM	0.215	0.044	4.855	***
SRMR	⟵	SPSM	0.115	0.053	2.166	0.03
SRMR	⟵	SCMS	0.459	0.06	7.662	***
SPMF	⟵	SRMR	0.264	0.046	5.78	***

7.3.3 Application of graph theory in cultivating the preferred supplier relationships

The structural framework obtained in the previous section certainly assist a manufacturer in cultivating the preferred supplier relationships with its key suppliers. Nonetheless, in order to establish more pragmatic way in cultivating the preferred supplier relationships, it was proposed that the structural framework is further studied by applying Graph Theoretic Approach (GTA). Anand and Bahinipati (2012) mentioned that the representations using GTA provide more clarity for a decision maker about the situations in contrast to the conventional representations like block diagrams, cause and effect diagrams and flow charts. Thus, in the current context the application of GTA was proposed to enable a manufacturer for determining the extent to which it can cultivate the preferred supplier relationships with its key suppliers and in the process have the essential discretion derived in supplier relationship development. In applying the GTA, a manufacturer must have selected the key suppliers beforehand with whom it wants the development of preferred supplier relationships to be quantified. After selecting the preferred suppliers, the following procedural steps can be followed by a manufacturer in applying the GTA:

Step 1 Draw the experts (who are closely associated with the suppliers) from the manufacturer side to collect the necessary responses in the process.

Step 2 Empathize the latent and observed variables in the structural framework obtained after applying the structural equation model.

Step 3 Develop a two-level graphical structure with latent variables and their corresponding observed variables as nodes. Position the latent variables at the top level and their corresponding observed variables at the bottom level and join the nodes at the top level with the edges in accordance to the tested relationships between the latent variables.

Step 4 The edges joining the two nodes of the graph (unidirectional/ bidirectional) represent the interdependency between the latent variables at the top level and between the observed variables of each latent variable at the bottom level.

Step 5 Assign a weight b_{ij} (see Table 7.9) for the all directed edges between the graph nodes to quantify the level of interdependency between members at the same level.

Step 6 Collect the performances along the observed variables qualitatively and accordingly quantify them on a scale 1-9 (see Table 7.10). A high value of 9 indicates extremely high performance along the performance index, while 1 indicates extremely poor performance.

Step 7 Develop a Variable Permanent Matrix (VPM) of each latent variable in which all diagonal terms represent the performances of corresponding observed variables under the latent variable and non-diagonal terms represent the extent to which each observed variable positively influences other observed variable.

Step 8 Develop a VPM for a preferred supplier program in which all the diagonal terms are filled with the permanent values of VPMs of latent variables. The non-diagonal elements of VPM for the preferred supplier program are filled by the interdependencies between the latent variables. Then, calculate the permanent value of VPM for the preferred supplier program. The aforementioned permanent value is nothing but a function of a matrix similar to that of a determinant. The permanent equation say Per (B) for any 4*4 matrix is defined mathematically as mentioned below,

$$
\begin{aligned}
Per\ (B) = \quad & B^1B^2B^3B^4 + b_{12}b_{21}B^3B^4 + b_{13}b_{31}B^2B^4 + b_{14}b_{41}B^2B^3 + b_{23}b_{32}B^1B^4 \\
& + b_{24}b_{42}B^1B^3 + b_{23}b_{32}B^1B^4 + b_{34}b_{43}B^1B^2 + b_{12}b_{23}b_{31}B^4 + b_{21}b_{32}b_{13}B^4 \\
& + b_{12}b_{24}b_{41}B^3 + b_{21}b_{42}b_{14}B^3 + b_{13}b_{34}b_{14}B^2 + b_{41}b_{43}b_{31}B^2 \\
& + b_{23}b_{34}b_{42}B^1 + b_{32}b_{43}b_{24}B^1 + b_{12}b_{21}b_{34}b_{43} + b_{13}b_{31}b_{24}b_{42} \\
& + b_{14}b_{41}b_{23}b_{32} + b_{12}b_{23}b_{34}b_{41} + b_{14}b_{43}b_{32}b_{21} + b_{13}b_{34}b_{42}b_{21} \\
& + b_{12}b_{24}b_{31} + b_{14}b_{42}b_{23}b_{31} + b_{13}b_{32}b_{24}b_{41}
\end{aligned}
$$

The matrix is defined as $B = \begin{pmatrix} B^1 & b_{12} & b_{13} & b_{14} \\ b_{21} & B^2 & b_{23} & b_{24} \\ b_{31} & b_{32} & B^3 & b_{34} \\ b_{41} & b_{42} & b_{43} & B^4 \end{pmatrix}$

Step 9 The permanent value of VPM for a preferred supplier program (calculated in the previous step) is expressed as Preferred Supplier Program Implementation Performance Index (PSPIPI). Generally this value would be quite high therefore, $\log_{10}(PSPIPI)$ is used to reduce the PSPIPI into a smaller number called the crisp value of the PSPIPI.

Step 10 Calculate the crisp values of PSPIPI for different case situations.

Step 11 Compare the crisp values of PSPIPI across different periods to establish a relationship between company's performances along the timeline.

Step 12 Plot a graph with timeline on X-axis and crisp values of PSPIPI with the chosen preferred supplier on Y-axis along with the lines at PSPIPIs obtained across various case situations to visualize the implementation performance of a preferred supplier program.

Table 7.9 Scale for measuring interdependency

Qualitative measure of interdependency	Quantified value
Very strong	5
Strong	4
Medium	3
Weak	2
Very Weak	1

Table 7.10 Scale for measuring performance of observed variables

Performance rating	Qualitative expression
1	Extremely poor performance
2	Very poor performance
3	Poor performance
4	Marginally poor performance
5	Average performance
6	Marginally high performance
7	High performance
8	Very high performance
9	Extremely high performance

Table 7.11 Performance and interdependency rating under different case situations

Ratings	Theoretically Best (TB)	Ideally Worst (IW)	Practically Best (PB)	Practically Achievable (PA)	Worst (W)
Performance	9	1	9	Feasible	1
Interdependencies	5	1	As rated according to the environment	As rated according to the environment	As rated according to the environment

7.4 Case application

In order to understand the practical relevance of the structural framework and the application of GTA, the current research work was presented in an electronic manufacturing company located in the southern part of India. The purchasing head of the company shown interest in the work and agreed to conduct case study of the company. Since the manufacturing environment was very competitive and the information about the suppliers was very confidential for the company the identities of the manufacturer and suppliers are not disclosed in the discussion. From here on in the current discussion, the manufacturer is referred as company ‘R’. The company ‘R’ is a well-known electronic manufacturing company making high end technology systems mainly for automotive, railway, healthcare, energy and aerospace industries. The company has been very aggressive player in making innovative products responsively with unique competitive advantages. As per the procedural steps detailed in the Section 7.3.3, five prominent preferred suppliers (named as S_1, S_2, S_3, S_4, and S_5) were chosen to quantify the extents of preferred supplier programs. According to the procedural steps, the experts were drawn from the case company who are closely associated with suppliers. The obtained structural framework, latent variables and their corresponding observed variables were explained to the experts. Subsequently on the basis of experts’ opinions, the PSPIPIs for all the suppliers were calculated along the timeline for a period of six quarters i.e. from 2014-2015. Further, the GTA was applied to under different case situations for providing various limits in developing preferred supplier relationships. The different case situations are briefly discussed below,

7.4.1 Possible case situations in cultivating preferred supplier relationships

A manufacturer implementing preferred supplier programs can determine the extent to which preferred supplier relationships can be cultivated by considering different case situations. Grover et al. (2005) and Anand and Bahinipati (2012) have proposed the said case situation analysis in the application GTA in their research studies. The case situations namely theoretically best, practically best, practically achievable, worst and ideal worst-case situation are formulated by varying the degree of weights assigned for capturing the interdependencies between observed variables and performance ratings. These differences with respect to the case situations are presented in the Table 7.11. For example, the theoretically best case situation is briefly explained as follows,

7.4.1.1 Theoretically best case situation

In this case situation, the theoretically maximum values are chosen in rating both the interdependencies and performances in quantifying the efficacy of a preferred supplier program. In this regard, the diagonal elements along the observed variables (i.e. in a VPM of latent variable) were filled with 9 (maximum performance rating) and other elements with 5 (maximum interdependence). Then diagonal elements of the VPMs of each preferred supplier program were filled with the permanent values of the VPMs of latent variables and the non-diagonal elements are filled with 5. Finally, the PSPIPIs under this case were calculated and converted on a logarithmic scale.

Similarly, for all the case situations according to the entries shown in the Table 7.11, the PSPIPIs for all the preferred supplier programs with the five suppliers along different points of timeline (i.e. for six quarters) were calculated and plotted on a graph (see Figure 7.3). In the current discussion, the results obtained for supplier S_1 alone are shown in order to concisely present the utility of the process.

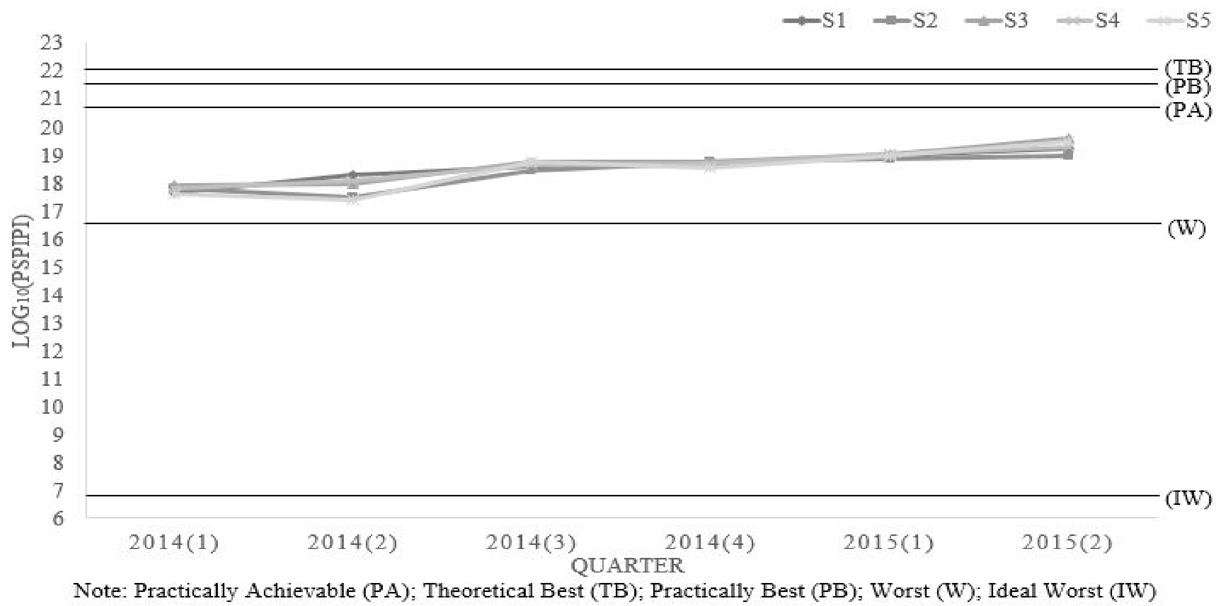


Figure 7.3 Performance plot of preferred supplier programs at the suppliers

7.5 Results and discussions

According to the research methodology, the data collected through a survey instrument was subjected to factor analysis. Through EFA, five principal components were extracted and then a measurement model was constructed using CFA. On the basis of measurement model obtained through CFA, the conceptual model comprising of six hypotheses were tested by applying path analysis. After testing the significance of each hypothesized relationship, the structural framework for cultivating preferred supplier relationships was established. The six hypotheses conceived were all found to be significant on the basis of response data collected data through the survey instrument. However, the standardized estimates calculated along the relationships are at different degrees to ponder. The most significantly related variables were SCMS and SRMR, SCMS and SPSM, and SCMS and SSAM. This result was supported by the experts that in the Indian manufacturing environment much of the basis in dealing with suppliers is based on how compatible the suppliers are with the manufacturing systems at the manufacturers. Although, SPSM and SRMR, SSAM and SPSM, and SSAM and SRMR are significantly related the estimates are relatively not strong as expected. The argument in support to this result was, in the Indian manufacturing environment still the suppliers are not greatly evolved to elaborately practice extending preferential support to the manufacturers as well as to strategically align with the manufacturers. Since, these relationships have combined effect on the relationship between SRMR and SPMF, the standardized regression weight estimate for SRMR and SPMF has also come down. From these results, it can be inferred that most of the manufacturers in the Indian manufacturing environment in cultivating preferred supplier relationships are laying the emphasis vastly on the compatibility of the suppliers with their manufacturing systems. Nonetheless, the preferential support and strategic alignment of the suppliers are significantly valued. Thus, those suppliers having compatible manufacturing systems, offering preferential support to the manufacturers, and trying to strategically align with the manufacturers can warrant them preferred supplier relationship from the manufacturers. Ultimately through these efforts, suppliers' response to the manufacturer's requirements and their potential for a manufacturer's growth are expected from the suppliers in ascribing preferred supplier status. From manufacturer's perspective, a manufacturer in the Indian manufacturing environment can use the structural framework as a basis in cultivating preferred supplier relationships with its key suppliers.

As mentioned earlier, by applying GTA on the structural framework established for cultivating the preferred supplier relationships, a manufacturer can derive a more pragmatic way for efficaciously practicing the preferred supplier concept. The case application discussed in the Section 7.4 produced certain important observations from the process. Since, relationships with the suppliers are more dynamic nature, quantifying the performance of preferred supplier programs with the suppliers enable a manufacturer to comprehend the evolution and deviations (if any) over a period of time. A plot was generated by graphing the performances of preferred supplier programs at the case company with its five suppliers over a period of six quarters from 2014-2015. The operating extents for the suppliers were 20.75 (for practically achievable case situation) and 16.66 (for worst case situation). Initially the suppliers were rated in between 17.60 and 17.89 which was not so far from worst case situation. However, at sixth quarter the PSSs were grown and were in between 18.98 and 19.58. Hence, the plot shows that the manufacturer has been positively developing the preferred supplier relationships with all its five suppliers. The plot has also marked with the expected performance values of the manufacturers preferred supplier programs under different case situations. Through these a manufacturer can have a reference to assess the extent to which preferred supplier relationship with a supplier can be achieved. It helps a manufacturers to reasonably persuade with the suppliers and also ensure the relationship with suppliers do not decline to worst case situations. With regards to the case company, the obtained results were positive and it was recommended that the manufacturer can extend the process with other suppliers and apply GTA for every quarter to generate preferred supplier relationship trends.

7.6 Sectional summary

Supplier relationships have become the eminent sources for the manufacturers in creating sustainable competitive advantages. In this regard, most of the manufacturers are inclined in cultivating preferred supplier relationships with their key suppliers so to strategically establish an appropriate supply base which is capable of competitively meeting their long term requirements. Although, the concept of preferred supplier has been a matter of interest for both manufacturers and suppliers and there is a dearth of studies conducted for cultivating preferred supplier relationships especially in a manufacturing environment like India. Thus, in this study, the considerations that a manufacturer must pursue in cultivating the preferred supplier relationships were examined and a structural framework was established. It was found that fundamentally the manufacturers in Indian manufacturing environment are vastly laying emphasis on suppliers' compatibility with their manufacturing systems in ascribing preferential status. Further, the preferential support offered by suppliers and the suppliers' initiatives for strategic alignment with the manufacturers are significantly valued. At long last in cultivating the preferred supplier relationships, the manufacturers expect for suppliers' response to their requirements and the competence offered for the manufacturers' furtherance. Besides the structural framework, the application of GTA was proposed so as to bring in more pragmatic way for a manufacturer's assistance in exercising the preferred supplier concept. The process was capable of providing a basis for a manufacturer to quantify the extent to which the preferred supplier relationships can be cultivated with the suppliers. It helps a manufacturer to assess the evolution or devolution in the preferred supplier relationships with the suppliers over a period of time. The process was tried in an Indian electronic manufacturing company and the results obtained were in favor of the case company. The manufacturer was recommended to timely practice the application of process and generate the trends in cultivating preferred supplier relationships. Since, the study was conducted in the context of a developing country like India where most of the global supply chains, have the suppliers the current study can be a worthy contribution both in research and practice.

Chapter 8

Framework for Evolving Preferred Customer Relationships

8 Sectional abstract

Suppliers have become discriminatory in the manufacturer-supplier relationships due to their improved power equations along the Manufacturing Supply Chains (MSCs). Consequently, often the manufacturing-customers have to compete for Preferred Customer Status (PCS) from their key suppliers (operating along multiple MSCs) to ensure a supportable supply base. However, it is difficult for a manufacturing-customer to perceive suppliers' perspectives, transform through the evolution of manufacturer-supplier relationships and warrant its precedence towards preferential advantages. Therefore, the essential and necessary aspects that position a manufacturer as a preferred manufacturing-customer are analyzed in the current study. In this regard, factor analysis was conducted to extract certain principal components for cultivating preferred customer relationships. Further, the conceptual relationships among the principal components were hypothesized and tested through path analysis to establish a structural framework. Finally, the Graph Theoretic Approach (GTA) was applied to determine the extents for which a manufacturer can cultivate the preferred customer relationships.

8.1 Necessity for a framework for cultivating preferred customer relations

The manufacturer-supplier relationships are becoming increasingly significant and also have been vastly transformed due to the changes in the power equations along supply chains and competition between the supply chains. However, due to the presence of several tiers of suppliers, still the supply segment along the supply chains is attributed as a weakest link posing serious challenges for the manufacturers (Beske and Seuring, 2014). Although manufacturers often take up initiatives like SDPs so as to strengthen their supply bases, the improvement achieved is best influenced by cultivating preferred customer relationships. This influence can be clearly seen when the suppliers are part of multiple supply chains and a manufacturer has to compete for the same type of resources (Pulles et al., 2015) and when there is scarcity of good suppliers (Steinle and Schiele, 2008). Moreover, since the suppliers also have become evaluative in extending the preferences to their manufacturing customers (Schiele, Veldman, et al., 2012), the manufacturers have to consciously apply reverse marketing approach in dealing with the suppliers (Schiele, Calvi, et al., 2012). Recently, many researchers have pointed out the advantages of preferred customer relationships while dealing with the changed power equations and increased supply chain competition (Schiele, Calvi, et al., 2012; Ellis et al., 2012; Hüttinger et al., 2012; Nollet et al., 2012; Pulles et al., 2015; and Kumar and Routroy, 2016).

Since the suppliers have earned strategic roles to play in the value addition process, depending on the best suppliers generate sustainable competitive advantages. In this regard, Schiele and Vos (2015) contended the idea of supplier obstructionism due to increase in a manufacturer’s dependency provided when the preferred customer relationships are cultivated. The PCS warrants dependency on the specialized suppliers and enables the manufacturers to focus more on their core competencies as well as derive competitive supplies made with the help of the suppliers (Kumar and Routroy, 2016). With the growing supply chain competition, it is beneficial to depend on the suppliers for technological innovations (Ellis et al., 2012). Despite the fact that the concept of preferred customer can influence the suppliers to be favorably dispositioned towards a manufacturer, it was not actively focused in the published literature (Kumar and Routroy, 2016). Specifically, there are no dedicated studies available for practicing the preferred customer concept in the context of a developing country like India. Since most of the suppliers are located in the developing countries like India, the current study can be a matter of interest for many supply chain managers. In the current study, the essential aspects through which a manufacturer can attain PCS are identified and empirically examined. In conducting the said empirical analysis, a survey instrument was developed and administered to the industry experts drawn from Indian manufacturing environment. The obtained response data was subjected to factor analysis and the principal components were extracted using statistical software package SPSS 20. Then, the principal components were conceptually linked together on the basis of literature review and industry experts' opinions. These links were further tested for statistical significance on the basis of the response data collected by applying path analysis using a statistical software package AMOS 20. The statistically validated model was considered as a generic framework for a manufacturer to attain PCS. Further, the structural framework was used in the application of Graph Theoretic Approach (GTA) through that a manufacturer can assess the extent to which the preferred customer relationships can be developed. The next section details the excerpts drawn from the published literature supporting the development of preferred customer relationships.

8.2 Literature review in support of conceptual model development

In this section, the possible conceptual directions for a manufacturer to achieve PCS are excerpted from the published literature. The PCS is usually referred as a behavioral aspect of the suppliers offering special privilege to a manufacturer (often implicitly extended) in comparison to other manufacturing customers (Schiele et al., 2011). Manufacturer is expected to be excellent in the knowledge management and capable of capturing, adopting and adapting to the advanced business trends, methods, processes and practices and disseminate to the suppliers (Jutla et al., 2001; Kokkonen and Tuohino, 2007; and Schiele et al., 2011). Functionally, a manufacturer is expected to be specialized in the leveraging core competencies and have sustainable competitive advantages developed (Christiansen and Maltz, 2002; and Ellis et al., 2012). Besides knowledge management, it must have well established flexible manufacturing systems capable of incorporating the reengineering of the products and services along with proper supplier management (Nollet et al., 2012; and Kumar and Routroy, 2015). Further, efficiency in accommodating responsibilities, compliance to the promised deliverables, ethical conduct, social performance and environmental conscious manufacturing practices draw suppliers' attention (Jacobsen, 2011; and Nollet et al., 2012). In this regard, suppliers also look for a manufacturer who is well-known in the industry and is capable of collectively generating supply chain innovation through its stakeholders (Smals and Smits, 2012). The strength of leadership and top management's consistent involvement in improving the business processes and initiatives taken to instill the essential confidence among the stakeholders induce the suppliers (Kumar and Routroy, 2016). Further, through effective strategies, proactive decisions, essential emphasis on the proposed initiatives and the support extended by the manufacturer makes the suppliers well-dispositioned (Ballou et al., 2000). So far the discussion was related to a manufacturers' capabilities that motivate a supplier to ascribe PCS.

Besides manufacturers' capabilities, most of the suppliers are concerned about the payables outstanding from the manufacturers. Manufacturers are perceived as preferred manufacturing customers if the payments are made on time to upkeep the cash flow cycles at their suppliers (Nollet et al., 2012). Moreover, suppliers expect that the payments made by the manufacturers are willful, transparent, virtuous and compensating in nature (Buttle, 1999; and Schiele et al., 2015). Apart from the payments, the suppliers also look for allocation of resources and win-win rights and returns shared on the suppliers' contributions and innovations (Hawes et al., 2006; and Schiele, Veldman, et al., 2012). Besides the positive flows, suppliers also calculate the costs incurred because of the manufacturers and count the mechanisms made by the manufacturers for suppliers' cost savings (Ellis et al., 2012). Further, suppliers are deciphered with right information, opinions are sought and are timely involved in the processes (Makkonen et al., 2015; and Bemelmans et al., 2015). Suppliers' suggestions are valued and given adequate flexibility in the utilization of manufacturer's resources depending upon the uncertainties encountered and complexity involved in the manufacturer's proposed initiatives (Kumar and Routroy, 2016).

Having said about a manufacturer's excellence and the essential flows from a preferred manufacturer to its suppliers, the possible influences on others aspects mentioned in the literature are to be explored. In achieving PCS, Schiele et al. (2011) pointed out that it is a manufacturer's attractiveness that preliminarily enables the manufacturer to achieve supplier commitment. Since, it is a reverse marketing approach, a manufacturer's excellence must attract the suppliers (Schiele, Calvi, et al., 2012). Suppliers look for a manufacturer capable of winning and transferring the orders and create future orders by responsively adopting and adapting to the changing market requirements (Hottenstein, 1970; Tóth et al., 2015; and Makkonen et al., 2015). Effective planning, communication and direction of resources towards the targeted mission and vision statements motivate the suppliers (Routroy and Kumar, 2015). Also, suppliers look for a manufacturer that has a commendable position, market share and growth, and global presence in the industry (Nollet et al., 2012; and Hüttinger et al., 2012). Manufacturer's products and services must be competitive with certain brand value, have proper market segmentation and adequate product variety (Lacoste, 2012). Besides highly valued products and services, they must have better availability in the marketplace with superior supply chain performance (Myers and Cheung, 2008). In this regard, manufacturer's competitive strategies must best fit with the supply chain strategies and competitively meet its customer requirements (Chopra and Meindl, 2007).

The abovementioned supply chain flows transferred to the supplier from manufacturer and manufacturer's attractiveness must indeed inspire the suppliers. In this regard, good suppliers with respect to their relational benefits and contributions must be appropriately recognized through various motivating mechanisms (Christiansen and Maltz, 2002; and Lacoste, 2012). Guaranteed or increased percentage of business from the manufacturer is the most commonly proposed aspect used for inspiring the suppliers (Schiele, 2012). Suppliers foresee cost reduction and improvement opportunities while associating with their manufacturing customers (Ellis et al., 2012). Due to the improved power equations, suppliers are also evaluating for win-win situations along the manufacturers' strategies and initiatives (Schiele, Calvi, et al., 2012; and Baxter and Kleinaltenkamp, 2015). Further, manufacturers must give away awards to acknowledge and certify the suppliers in order to acknowledge their contributions in the value addition process (Routroy and Kumar, 2015). Beyond these, the best contributing suppliers look for relationship specific benefits such as dedicated investments and preferred supplier status (Lager and Storm, 2012; and Andersen et al., 2015). Suppliers also expect from the manufacturers that in the forward marketing the competitive advantages gained from the suppliers are actively endorsed, promoted and recommended to the peers (Bendixen et al., 2004).

Besides the above mentioned aspects, in ascribing the PCS to the manufacturing customers the suppliers look for collective efforts in the value addition process (Myers and Cheung, 2008; and Luzzini et al., 2015). Development of mutual trust has been the most important ingredient in safeguarding the manufacturer-supplier interests besides the improvement in the transactions (Nollet et al., 2012; and Luzzini et al., 2015). In this regard, the manufacturer-supplier must have strategic investments made in each other in view of meeting their long term business requirements (Baxter, 2012). Suppliers expect that manufacturer-supplier have appropriate mechanisms to interact and arrive at consensus in the decision making of strategies and problem solving (Lacoste, 2012). The said mechanisms are systematic, scientific and professional without jeopardizing the stakeholders' interests. The processes and practices are timely standardized in compliance to the industry best standards (Hüttinger et al., 2012). However, the top to bottom line workforce must have conducive environment established in order to implement the processes and practices and smoothly carryout the manufacturer-supplier transactions (Williamson, 1991). Through these, the suppliers look for competitive learning curves established with the help of a manufacturer and in turn the increase the value generated (Fawcett et al., 2007). The systems perspective must ensure in between a manufacturer-supplier with a view of generating improved supply chain profit (Kumar and Routroy, 2016). Even though the manufacturer and supplier may be independent enterprises, strategically, tactically and operationally manufacturer-supplier must not be significantly different (Bemelmans et al., 2015). The manufacturer-supplier specific transactions should have been greatly improved and mostly automated. The manufacturer-supplier requirements, interests and concerns are systematically, responsively, accurately defined; timely communicated; and implemented (Kumar and Routroy, 2016). The manufacturing systems of practice at both manufacturer-supplier should have been optimized for improved productivity. Finally, the understanding between manufacturer-supplier must be so evolved such that the probable negative effects (i.e. uncertainties, conflicts and risks) that can arouse are thoroughly predicated, analyzed and resolved in advance (Nollet et al., 2012).

The abovementioned excerpts from the literature review indicate that a comprehensive directional framework can be established for achieving the preferred customer relationships with the suppliers. In this regard, on the basis of literature review discussed in this section, certain hypotheses will be formulated in the later sections to empirically test the significance of theoretical conceptions.

8.3 Research methodology

The research methodology followed in this study entails three parts i.e. factor analysis for extracting the principal components to focus in achieving PCS; establishing structural framework for practicing the preferred customer concept; and analysis of evolution of PCS of a manufacturer using GTA.

8.3.1 Factor analysis to extract the principal components for achieving PCS

In conducting the current study, a survey questionnaire was developed along the prominent aspects that drive the suppliers to ascribe PCS to a manufacturer. It was developed on the basis of literature review, brain storming sessions and discussions held with the academic and industry experts in India. The current form of the questionnaire was obtained after conducting a pilot study through a focused of industry experts drawn from Indian manufacturing environment. As per the experts' opinions, the questionnaire was made simple, comprehensive and concise in nature. It was then shared with the industry experts drawn from Indian manufacturing environment in order to extract the practical scenario for a manufacturer in achieving PCS. They were asked to express their opinions on a Likert scale of 1 to 5, where 1: Strongly disagree, 2: Disagree, 3: Neutral, 4: Agree and 5: Strongly Agree. In collecting the data, authors have conducted several industrial visits to the manufacturing companies located in the northern and southern parts of India and personally recorded the experts' opinions. Apart from the personal interviews, the questionnaire was also sent to the experts by accessing the contact details of the companies from the databases of Confederation of Indian Industries (CII) and Gujarat Industrial Development Corporation (GIDC). Authors could reach the experts through telephonic conversations, internet audio calls, web meetings, emails, shared online spread sheets and by posting the hard copies of the questionnaire. Further, the industry experts were also interacted during several international conferences, industrial summits, workshops and exhibitions. The experts approached in the study were mostly designated as chief purchasing officers, procurement and supply heads, general managers, assistant general managers, senior managers, supplier quality engineers, senior engineering managers, SD officers (or) engineers (or) managers. The designations and the industry wise percentage distribution of experts are shown in the Table 8.1 and Table 8.2 respectively. The experts consulted were having more than eight years of experience in the industry and were all professionally qualified with degrees in engineering and business administration. Overall 1560 number of experts were contacted in the data collection, but out of which 436 responses were obtained. Further, after cleaning the data (using statistical software SPSS 20) 396 responses were found to be useful with an overall response rate of 25.38%. The sample size was considered to be sufficient for data analysis as it was ten times the number of observed variables (i.e. 37 number of questions in the questionnaire). On the basis of collected data along the observed variables, the factor analysis was applied to extract the principal components to focus in achieving PCS. However, before conducting the factor analysis, the essential conditions justifying the validity of applying factor analysis were checked. The conditional checks conducted were on the basis of Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, Bartlett's test of sphericity and an anti-image correlation matrix. The results obtained under KMO and Bartlett's tests (which indicate the presence of correlation between the observed variables) are show in the Table 8.3. Since, the obtained KMO measure was 0.877 while the minimum value must be 0.5 the conditional check was fulfilled. Under Bartlett's test of sphericity, the P-value obtained was also significant suggesting the application of factor analysis on the response data. Finally, for applying factor analysis the anti-image correlation matrix must have negative partial correlations and the diagonal elements must be greater than 0.5. Since, there were negative partial correlations in the obtained anti-image correlation matrix and the lowest among the diagonal elements was 0.826 the application of factor analysis was supported. Since, all the conditional checks were passed the factor analysis was applied to extract the principal components for achieving PCS.

Table 8.1 Levels of respondents participated in the study

Level	Frequency	Percentage
Engineer/ Assistant Manager level	121	31
Senior Engineer/ Manager level	166	42
General Manager /Chief Engineer level	78	20
Purchasing and supply heads and above	35	7
Total	396	100

Table 8.2 Industry wise frequencies of the respondents participated in the study

Company Type	Industry Group	Frequency	Percentage (%)
Automotive	1	81	20
Electronics	2	56	14
Aerospace	3	46	12
Industrial equipment	4	43	11
Energy equipment manufacturing	5	36	9
Non-durable consumer products	6	36	9
Materials and Construction	7	35	9
Pharmaceuticals and biotechnology	8	24	6
Food, Beverage	9	21	5
Metals and Mining	10	18	5
Total		396	100.0

Table 8.3 Kaiser-Meyer-Olkin and Bartlett's test results

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.877
Bartlett's Test of Sphericity	Approx. Chi-Square	16351.778
	Df	630
	Sig.	.000

8.3.1.1 Exploratory Factor Analysis

Under factor analysis, the Exploratory Factor Analysis (EFA) was applied to explore the underlying pattern and then reduce the observed variables into smaller group of components called as principal components or latent variables. The extraction of principal components was carried out by applying Principal Component Analysis (PCA) as an extraction method and Varimax as a method of rotation using SPSS 20. While extracting the principal components, as a Kaiser criterion the Eigen value was set at ‘1’. Totally six principal components were extracted by applying EFA with a total variance of 79.521% explained as shown in the Table 8.4. Scree plot (see Figure 8.1) also shows the five components extracted along the Eigen values (indicates the portion of total variance explained the components). These components were termed as Efficiency in the Supply Chain Flows to the supplier (ESCF), Motivational Aspects Experienced by the Supplier (MAES), Manufacturer’s Efficient and Effective Program (MEEP), Manufacturer's Attractive Business Conduct (MABC), Manufacturer's Stability, Capability and Development (MSCD), and Manufacturer-supplier Collective Engagement (MSCE). On the basis of communalities (which indicate the relevance of observed variables in accounting the variance explained by latent variables) obtained from the SPSS output the weakly ones (i.e. < 0.5) can be eliminated. So, the variable MSCD7 was eliminated as it was less than 0.5. Further, in the SPSS output the rotated component matrix obtained by applying PCA as an extraction method and Varimax with Kaiser Normalization as rotation. This matrix shows the correlations among the observed variables and the latent variables which are also called as factor loadings. The grouping of observed variables along the latent variables was based on the factor loadings typically greater than 0.5 and with no variable is having cross loading more than 0.4 with other latent variables. The obtained factor loadings obtained for observed variables and the latent variables are shown in the Table 8.5. At this juncture, the reliability analysis was conducted on the observed variables to ensure their consistency in defining the latent variables. The Chronbach's alpha was the value estimated in the reliability analysis. In order to clear the reliability test the observed variable must get the Chronbach's alpha more than 0.70. The Chronbach's alpha values obtained for the six latent variables were MSCD - 0.949, ESCF - 0.947, MABC - 0.936, MAES - 0.938, MSCE - 0.952, MEEP - 0.963. Since, all latent variables were having estimated Chronbach's alpha values more than 0.70 it was believed that the observed variables were consistent in defining their respective latent variables. Thus, these configurations of observed and latent variables were considered for further analyses.

8.3.1.2 Confirmatory Factor Analysis

Having extracted the principal components for achieving PCS and configured the sets of observed variables under the latent variables through EFA, in this section the application of Confirmatory Factor Analysis (CFA) is demonstrated. The CFA was applied to confirm that the observed variables significantly estimate their respective latent variables. In conducting the CFA, the relationships among the latent variables were modeled as a path diagram in AMOS 20. In the path diagram, all the 36 observed variables configured under six latent variables were related. Then, the estimates of the model were calculated and the model specifications were recorded. The initial model specifications obtained were $\chi^2 = 2861.970$, df = 579, $\chi^2/df = 4.943$, GFI = 0.711, AGFI = 0.668, RMSEA = 0.100, CFI = 0.860, RMR = 0.031. However, the permissible model specifications as shown in the Table 8.6 called for refinement in the model. Hence, the model was refined according to Wang and Ahmed (2004) and Janssens et al. (2008) till the model fit indices are at with the permissible model specifications. Initially the standardized residual covariances matrix was checked and ensured that no correlation was greater than |2.58|. Further, on the basis of modification indices obtained from the AMOS 20 the model was refined till the model specifications satisfied the permissible limits. The model specifications obtained after refining the model were $\chi^2 = 542.935$, df = 233, $\chi^2/df = 2.330$, GFI = 0.900, AGFI = 0.871, RMSEA = 0.028, CFI = 0.966, RMR = 0.058. Since, these model specifications were fulfilling the acceptable limits the measurement model was believed to be fit enough to make the estimates. Further, the fitted model was subjected to various tests such as unidimensionality (Janssens et al., 2008), convergent validity (Anderson and Gerbing, 1988), reliability (Gaskin, 2012) and discriminant validity (Hair et al., 2006) for making the authentic dimensions. Under unidimensionality test the critical ratios were ensured to be greater than 1.96. As the lowest among the obtained critical ratios was 16.532, it was certain that the model has unidimensionality. Under convergent validity, the standardized regression weights estimated for the pairs of observed and latent variables were ensured to be greater than 0.5 (Janssens et al., 2008). As the lowest value among the standardized regression weights was 0.693, the model was sought to have fulfilled the convergent validity. Under reliability test, the composite reliabilities were estimated and ensured that the values were more 0.7 (Gaskin, 2012). The values of composite reliabilities obtained for the latent variables MAES - 0.907, MSCE - 0.944, MABC - 0.905, ESCF - 0.920, MSCD - 0.941, and MEEP - 0.960. Since, the obtained composite reliabilities were all greater than 0.7, the model was considered to be reliable. Finally, under the discriminant validity test, it was ensured that the square root of Average Variance Explained (AVE) which are filled along the diagonal of a factor correlation matrix was greater than the correlations between the factors (see Table 8.7). Thus, the measurement model was considered to be good for calculating estimates, as all the conditions of unidimensionality, convergent validity, reliability, and discriminant validity were fulfilled.

Table 8.4 Total variance explained by the extracted components

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.001	33.336	33.336	12.001	33.336	33.336	5.599	15.552	15.552
2	5.503	15.286	48.622	5.503	15.286	48.622	4.833	13.426	28.978
3	3.968	11.022	59.644	3.968	11.022	59.644	4.820	13.389	42.367
4	3.530	9.806	69.450	3.530	9.806	69.450	4.529	12.581	54.947
5	2.018	5.604	75.054	2.018	5.604	75.054	4.439	12.331	67.279
6	1.608	4.467	79.521	1.608	4.467	79.521	4.407	12.243	79.521

Table 8.5 Rotated Component Matrix

Observed Variable	Component					
	1	2	3	4	5	6
MSCE2	.892	.076	.014	.138	.175	.245
MSCE5	.859	.094	.012	.122	.131	.269
MSCE1	.844	.041	-.010	.141	.046	.221
MSCE6	.832	.134	.053	.142	.145	.185
MSCE7	.819	.060	.011	.121	.074	.222
MSCE4	.795	.073	.018	.118	.181	.253
MSCE3	.749	.090	.114	.122	.136	.173
MSCD2	.107	.850	-.001	.245	.091	.123
MSCD5	.069	.841	-.069	.332	.106	.125
MSCD1	.069	.837	-.025	.200	-.036	.113
MSCD3	.114	.834	-.002	.264	.049	.083
MSCD4	.034	.826	-.056	.282	.033	.201
MSCD6	.129	.821	-.008	.272	.082	.142
ESCF2	.044	-.009	.905	.030	.077	.136
ESCF3	.033	-.001	.897	-.002	.038	.120
ESCF5	.013	-.015	.888	.000	.051	.137
ESCF4	-.025	-.034	.873	.025	.040	.154
ESCF1	.056	-.016	.865	.003	.010	.077
ESCF6	.067	-.048	.851	-.022	.100	.022
MABC5	.143	.301	.014	.843	.129	.124
MABC1	.163	.249	-.035	.834	.014	.080
MABC2	.108	.264	-.004	.833	.128	.106
MABC4	.145	.242	-.032	.776	.098	.168
MABC6	.183	.320	.072	.760	.121	.139
MABC3	.148	.271	.039	.744	.098	.063
MEEP5	.150	.049	.071	.087	.940	.117
MEEP4	.188	.046	.061	.085	.939	.099
MEEP2	.157	.073	.043	.106	.903	.030
MEEP1	.107	.064	.066	.081	.893	.081
MEEP3	.125	.042	.082	.129	.860	.102
MAES5	.240	.160	.127	.145	.159	.815
MAES2	.266	.166	.180	.158	.112	.808
MAES3	.319	.117	.138	.092	.015	.802
MAES4	.215	.160	.116	.151	.144	.789
MAES1	.287	.106	.131	.060	-.001	.770
MAES6	.362	.137	.131	.106	.111	.745

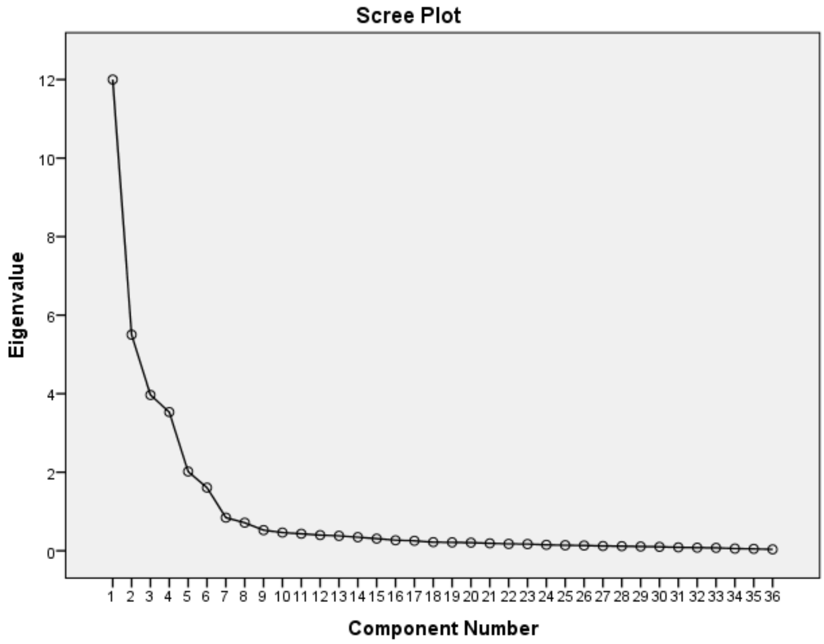


Figure 8.1 Scree plot showing the principal components extracted

Table 8.6 Permissible limits of model fit indices for an acceptable quality model

Model parameters	Permissible range	Citation
$\chi2/df$	≤3	Hu and Bentler (1999); Steiger (1990); Byrne (2013)
GFI	≥0.90	Mulaik et al. (1989)
AGFI	≥0.80	Bentler (1990); Hu and Bentler (1999)
RMSEA	≤0.10	Browne and Cudeck (1992)
CFI	≥0.90	McDonald and Marsh (1990)
RMR	≤0.14	Steiger (1990); Byrne (2013)

Table 8.7 Reliability and validity test results of latent variables

Latent Variable	CR	AVE	MSV	ASV	MAES	MSCE	MABC	ESCF	MSCD	MEEP
MAES	0.907	0.711	0.300	0.155	0.843					
MSCE	0.944	0.808	0.300	0.129	0.548	0.899				
MABC	0.905	0.706	0.377	0.148	0.392	0.367	0.840			
ESCF	0.920	0.744	0.084	0.025	0.290	0.108	0.055	0.863		
MSCD	0.941	0.800	0.377	0.119	0.363	0.242	0.614	-0.029	0.894	
MEEP	0.960	0.857	0.139	0.073	0.322	0.373	0.264	0.152	0.169	0.926

8.3.2 Structural framework for practicing the preferred customer concept

In this section, certain hypotheses were conceptually formulated and were tested for their significance in contributing towards achieving PCS. These hypotheses were formulated on the basis of literature review presented in the Section 8.2, brainstorming sessions and discussions held with the industry and academic experts. Further, on the basis of these hypotheses a conceptual model was developed and the directional relationships among the latent variables were tested through path analysis. In conducting the path analysis the measurement model obtained from CFA was remodeled as a path diagram in AMOS 20. There were six hypotheses formulated for testing the conceptual model and are mentioned below,

H_1: Manufacturer's stability, capability and development enhances the attractiveness of its business conduct

H_2: Efficiency in the supply chain flows to the supplier from the manufacturer improve the motivational aspects experienced by the supplier

H_3: Manufacturer's attractiveness through its business conduct increases the motivational aspects experienced by its supplier

H_4: Manufacturer's attractiveness through its business conduct causes manufacturer-supplier collective engagement

H_5: The motivational aspects experienced by the supplier positively influences manufacturer-supplier collective engagement.

H_6: A manufacturer-supplier collective engagement causes efficient and effective program at the manufacturer

The abovementioned hypotheses were modeled as a path diagram is AMOS 20 in order to test their significance and calculate the standardized estimates for these directed relationships among the latent variables. Then the path analysis was conducted and ensured that the model was fit enough to make valid estimates. In this regard the P-value for the model was ensured to be less than 0.05 which indicates that the estimated and sample covariance matrices are not significantly different. These estimates were based on the previously data collected along the observed variables in the questionnaire. The calculated estimates in the AMOS 20 clearly shown that the formulated hypotheses were all significant as their critical ratios were all much greater than 1.96 (see Table 8.8). The quality of the model was also good as the model specifications obtained were at par with the permissible limits. The model specifications obtained were χ^2 = 543.773, df = 239, χ^2/df = 2.275, GFI = 0.900, AGFI = 0.874, RMSEA = 0.057, CFI = 0.967, SRMR = 0.0391. Thus, the conceptual model was empirically validated and can be used by the manufacturers to efficaciously achieve PCS from their key suppliers. The statistically validated structural framework along with the standardized estimates for achieving PCS is shown in the Figure 8.2.

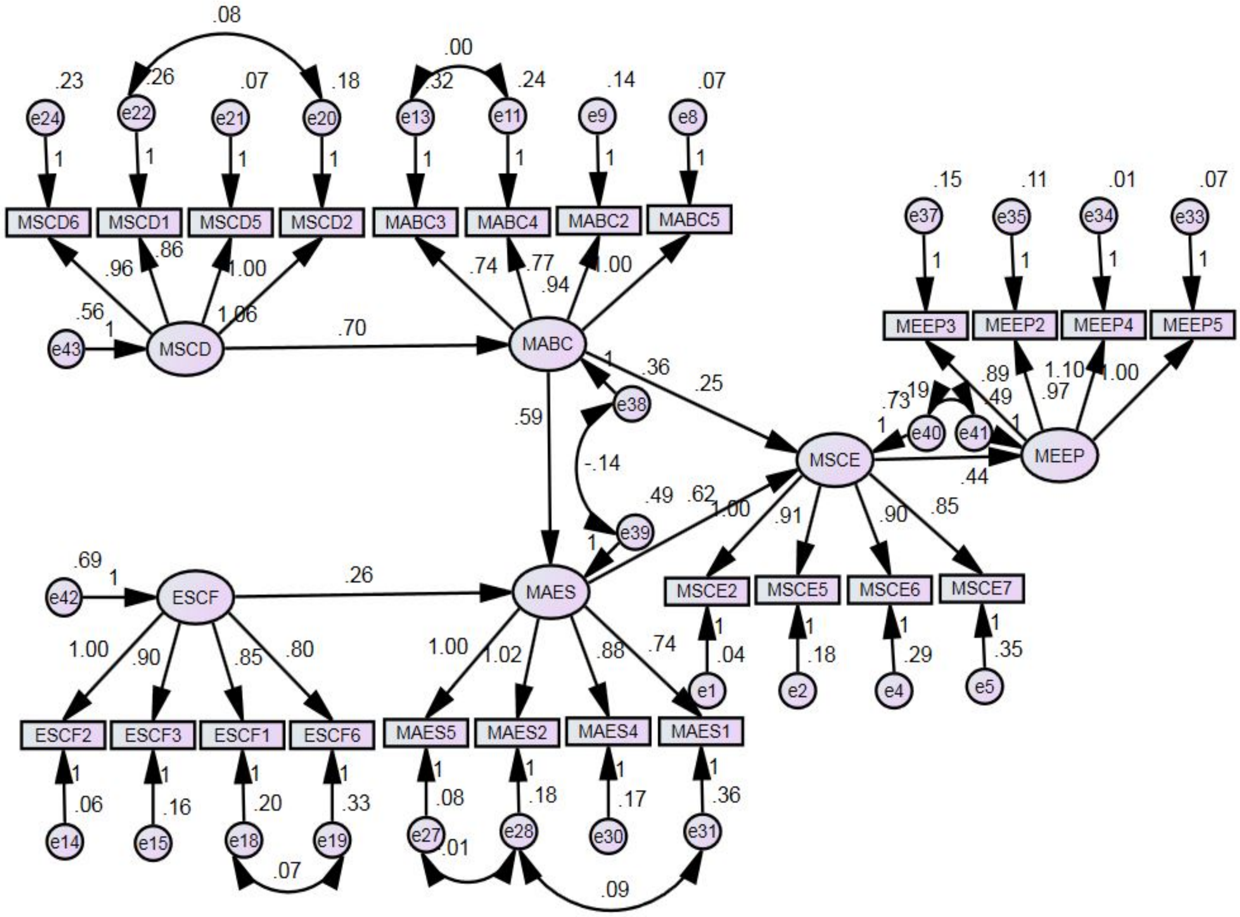


Figure 8.2 **Calculated estimates of hypothesized relationships through path analysis**

Table 8.8 Regression estimated weights of hypothetically related latent variables

Latent Variable	Directional relationship	Latent Variable	Estimate	S.E.	C.R.	P
SSAM	⟵	SCMS	0.701	0.05	14.084	***
SPSM	⟵	SSAM	0.263	0.044	6.017	***
SPSM	⟵	SCMS	0.586	0.075	7.864	***
SRMR	⟵	SSAM	0.251	0.06	4.194	***
SRMR	⟵	SPSM	0.625	0.066	9.465	***
SRMR	⟵	SCMS	0.437	0.063	6.954	***

8.3.3 Analyzing the evolution of PCS of a manufacturer using GTA

The empirically validated structural framework obtained in the previous section was further analyzed by applying the GTA so that a manufacturer can timely quantify the evolution of PCS and measure the extents in cultivating the PCS. In this regard, Anand and Bahinipati (2012) highlighted the superiority of GTA over block diagrams, cause and effect diagrams and flow charts in providing more clarity for a decision maker regarding the situations. However before applying the GTA, a manufacturer must select the key suppliers from whom it wants to quantify the evolution of its preferred customer relationships. After selecting the suppliers, the following procedural steps can be followed by a manufacturer in applying the GTA:

Step 1 Draw the experts (who are closely associated with the suppliers) from the manufacturer side to collect the necessary responses in the process.

Step 2 Comprehend the latent and observed variables in the structural framework obtained after conducting the path analysis.

Step 3 Develop a two-level graphical structure with latent variables and their corresponding observed variables as nodes. Position the latent variables at the top level and their corresponding observed variables at the bottom level and join the nodes at the top level with the edges in accordance to the tested relationships among the latent variables.

Step 4 The edges joining the two nodes of the graph (unidirectional/ bidirectional) represent the interdependency between the latent variables at the top level and between the observed variables of each latent variable at the bottom level.

Step 5 Assign a weight b_{ij} (see Table 8.9) for the all directed edges between the graph nodes to quantify the level of interdependency between members at the same level.

Step 6 Collect the performances along the observed variables qualitatively and accordingly quantify them on a scale 1-9 (see Table 8.10). A high value of 9 indicates extremely high performance along the performance index, while 1 indicates extremely poor performance.

Step 7 Develop a Variable Permanent Matrix (VPM) of each latent variable in which all diagonal terms represent the performances of corresponding observed variables under the latent variable and non-diagonal terms represent the extent to which each observed variable positively influences other observed variable.

Step 8 Develop a VPM for a preferred customer program in which all the diagonal terms are filled with the permanent values of VPMs of latent variables. The non-diagonal elements of VPM for the preferred customer program are filled by the interdependencies between the latent variables. Then, calculate the permanent value of VPM for a preferred customer program. The aforementioned permanent value is nothing but a function of a matrix similar to that of a determinant. The generalized permanent equation say Per (B) for any 4*4 matrix is defined mathematically as mentioned below,

$$
\begin{aligned}
Per\ (B) = \quad & B^1B^2B^3B^4 + b_{12}b_{21}B^3B^4 + b_{13}b_{31}B^2B^4 + b_{14}b_{41}B^2B^3 \\
& + b_{23}b_{32}B^1B^4 + b_{24}b_{42}B^1B^3 + b_{23}b_{32}B^1B^4 + b_{34}b_{43}B^1B^2 \\
& + b_{12}b_{23}b_{31}B^4 + b_{21}b_{32}b_{13}B^4 + b_{12}b_{24}b_{41}B^3 \\
& + b_{21}b_{42}b_{14}B^3 + b_{13}b_{34}b_{14}B^2 + b_{41}b_{43}b_{31}B^2 \\
& + b_{23}b_{34}b_{42}B^1 + b_{32}b_{43}b_{24}B^1 + b_{12}b_{21}b_{34}b_{43} \\
& + b_{13}b_{31}b_{24}b_{42} + b_{14}b_{41}b_{23}b_{32} + b_{12}b_{23}b_{34}b_{41} \\
& + b_{14}b_{43}b_{32}b_{21} + b_{13}b_{34}b_{42}b_{21} + b_{12}b_{24}b_{31} \\
& + b_{14}b_{42}b_{23}b_{31} + b_{13}b_{32}b_{24}b_{41}
\end{aligned}
$$

The matrix is defined as $B = \begin{pmatrix} B^1 & b_{12} & b_{13} & b_{14} \\ b_{21} & B^2 & b_{23} & b_{24} \\ b_{31} & b_{32} & B^3 & b_{34} \\ b_{41} & b_{42} & b_{43} & B^4 \end{pmatrix}$

Step 9 The permanent value of VPM for a preferred customer program (calculated in the previous step) is expressed as Preferred Customer Development Performance Index (PCDPI). Generally this value would be quite high therefore, $\log_{10}(PCDPI)$ is used to reduce the PCDPI into a smaller number called the crisp value of the PCDPI.

Step 10 Calculate the crisp values of PCDPI for different case situations.

Step 11 Compare the crisp values of PCDPI across different periods to establish a relationship between company's performances along the timeline.

Step 12 Plot a graph with timeline on X-axis and crisp values of PCDPI with the chosen supplier on Y-axis along with the lines at PCDPIs obtained across various case situations (see Tab1e 11) to visualize the implementation performance of a preferred supplier program.

Table 8.9 Scale for measuring interdependency

Qualitative measure of interdependency	Quantified value
Very strong	5
Strong	4
Medium	3
Weak	2
Very Weak	1

Table 8.10 Scale for measuring performance of observed variables

Performance rating	Qualitative expression
1	Extremely poor performance
2	Very poor performance
3	Poor performance
4	Marginally poor performance
5	Average performance
6	Marginally high performance
7	High performance
8	Very high performance
9	Extremely high performance

Table 11: Performance and interdependency rating under different case situations

Ratings	Theoretically Best (TB)	Ideally Worst (IW)	Practically Best (PB)	Practically Achievable (PA)	Worst (W)
Performance	9	1	9	Feasible	1
Interdependencies	5	1	As rated according to the environment	As rated according to the environment	As rated according to the environment

8.4 Case application

In order to demonstrate the utility of the structural framework and the application of GTA on the basis of it, a case study conducted in an Indian electronic manufacturing company is discussed. In order to protect the confidentiality of the company, from here on in the current discussion, the case company is referred as company 'S'. The company is located in the Southern part of India and is well-known for making high end technology systems. It has been into the manufacturing businesses of automotive, railway, healthcare, energy and aerospace industries. Since inception, it has been very aggressive player in making innovative products responsively with unique competitive advantages. As discussed in the Section 8.3.3, the company personnel were requested to consider five key suppliers (named as S_1, S_2, S_3, S_4, and S_5) from whom they want to quantify the evolution of preferred customer relationships. Then according to step 1, the experts (drawn from the case company) those who closely deal with suppliers were formed. The experts were shared with the obtained structural framework and were explained about the observed variables and the latent variables. Then, following the step 3 to step 11 the PCDPIs from all the suppliers for six quarters i.e. from 2014-2016 were calculated. Further, the GTA was applied in different case situations for generating the various limits in achieving preferred customer relationships with their suppliers. These case situations are briefly discussed below,

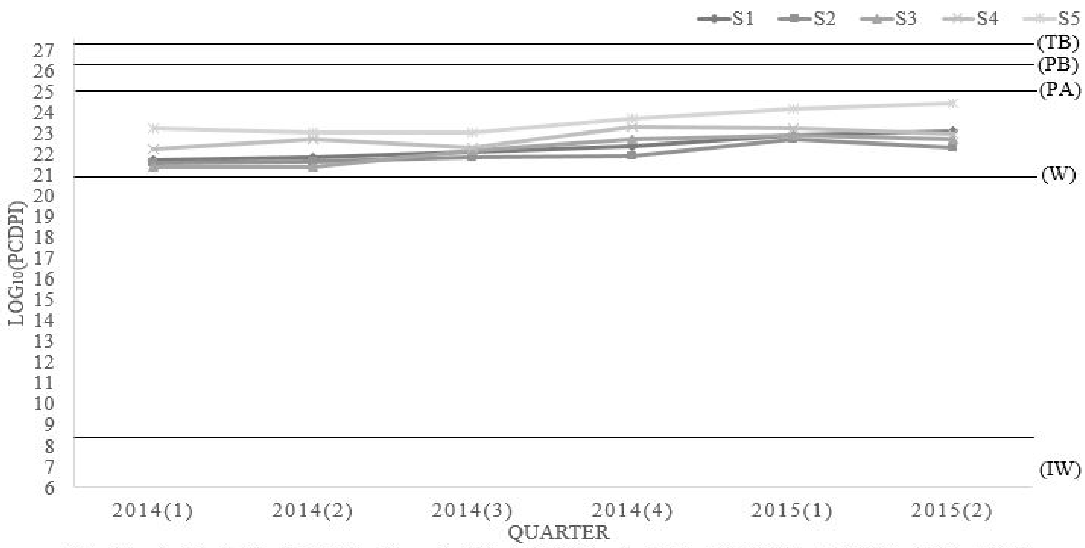
8.4.1 Possible case situations in cultivating preferred supplier relationships

A manufacturer developing the preferred customer relationships must have a basis to know the extent to which it can stretch in achieving PCS. It must also know the course of evolution in the preferred customer relationships along the suppliers. In this regard, several case situations were considered and the references are provided for the manufacturer in cultivating the preferred customer relationships. Grover et al. (2005) and Anand and Bahinipati (2012) proposed the said case situation analysis in the application GTA in their research studies. The case situations in the study were theoretically best, practically best, practically achievable, worst and ideal worst-case situations depending on the degree of weights assigned for capturing the interdependencies between observed variables and performance ratings. These differences among the case situations are presented in the Table 8.11. To constrain the discussion only the theoretically best case situation is briefly explained as follows,

8.4.1.1 Theoretically best case situation

In this case situation, the theoretically maximum values are used in rating both the interdependencies and the performances along the observed and latent variables for quantifying the efficacy of a manufacturer in achieving PCS. In this regard, the diagonal elements along the observed variables (i.e. in a VPM of latent variable) were filled with 9 (maximum performance rating) and other elements with 5 (maximum interdependence). Then the diagonal elements of the VPMs of each preferred customer program were filled with the permanent values of the VPMs of latent variables and the non-diagonal elements are filled with 5. Finally, the PCDPIs under this case were calculated and converted on a logarithmic scale.

Similarly, the PCDPIs were calculated for all the above mentioned case situations with respect to the entries shown in the Table 8.11. These PCDPIs for all the preferred customer programs of the five key suppliers along the different points of timeline (i.e. for six quarters) were calculated and plotted on a graph (see Figure 8.3). In the current discussion, the results obtained from supplier S_1 alone are shown in order to concisely present the utility of the process.



Note: Practically Achievable (PA); Theoretical Best (TB); Practically Best (PB); Worst (W); Ideal Worst (IW)

Figure 8.3 Performance plot of preferred customer programs with the suppliers

8.5 Results and discussion

In the current study, the prominent aspects that a manufacturer has to focus for achieving preferred customer relationships with its key suppliers were empirically examined. In this regard, a questionnaire was developed and the response data was collected from a sample of experts drawn from the Indian manufacturing environment. Then in order to reduce the dimensions, the collected data was processed by applying factor analysis. Overall, six principal components were extracted through EFA and then a measurement model was developed by applying CFA. Further, on the basis of this measurement model, a conceptual model having six hypotheses were tested by conducting path analysis. The estimates (along the hypothesized relationships) obtained from the path analysis had clearly shown that all the hypotheses were significant. This empirically validated conceptual model was considered as a structural framework that a manufacturer can use in developing preferred customer relationships. However, the standardized estimates calculated along the hypothesized relationships are at different degrees to ponder. Among all the relationships, the MSCD and MABC, MABC and MAES, and MAES and MSCE are the most significantly related. This can be understood that a manufacturer in achieving PCS must demonstrate stability, capability and development, have attractive business conduct, and extend motivational experiences to its suppliers so that, the manufacturer can collectively participate with it suppliers in the value addition process. Although, ESCF and MAES, and MABC and MSCE, were significantly related, the obtained estimates are relatively not strong as expected. This can be understood that the ESCF from the manufacturer is a kind of must-be attribute for the suppliers who presence may not delight but absence may lead to dissatisfaction of the suppliers. Similarly, MABC may also provide initial drive for the suppliers to favorably associate with the manufacturer, but to collectively take part with the manufacturers, the suppliers call for certain motivational mechanisms. Ultimately, suppliers expect that the collective engagement must lead favorable results such as improved efficiency and effectiveness. From these results, it can be inferred that the manufacturers have to achieve internal stability, capability and development, practice attractive business conduct and trigger motivational mechanisms for the suppliers. Since, the essential supply chain flows act as a must-be attribute, the manufacturers have to ensure that this component is not overlooked. Ultimately, if a supplier is collectively engaged with a manufacturer and have favorable results generated, then the manufacturer can expect for PCS from the supplier.

Having obtained the structural framework, the GTA was integrated to establish a basis for a manufacturer to assess its evolution towards practically achievable PCS and have reference levels in developing the PCS. The case study conducted for trying the process yielded some important observations. The performance of the case company as a preferred customer for its five key suppliers were plotted on a graph for over six quarters. From the plot, it can be observed that initially three (i.e. S_1, S_2 and S_3) out of five suppliers were close to the worst case situation. Even for the second quarter there was no serious improvement in these suppliers' attitudes, but there was slight improvement. In the third and fourth quarters, there was remarkable change in S_1, S_2 and S_3 suppliers in favorably perceiving the manufacturer. In the final two quarters, it can be seen that all the suppliers were progressively perceiving the manufacturer as a preferred customer. Among all the suppliers, the supplier S_5 was more favorably dispositioned towards the manufacturer and was consistently improving in perceiving the manufacturer as a preferred customer. So, the manufacturer was recommended to prefer and promote the supplier S_5 in comparison to the other suppliers and can also distinctively work with the suppliers in order to consistently improve its PCS. Overall, because of consciously working for PCS, the manufacturer could achieve favorable perception from its suppliers at the end of last two quarters despite some deviations in the initial two quarters. Experts' response about the current piece of research work was that, so far there was no explicit thought process for cultivating and evaluating its manufacturer's PCS. But with the help of the structural framework, when there were conscious efforts pursued by the manufacturer they could observe tremendous difference in the suppliers' approach. By highlighting its internal stability, capability and development; showcasing its attractive business conduct; and by introducing motivational mechanisms for the suppliers the manufacturer could see lot of improvement in its PCS. Most importantly by leveraging the essential supply chain flows along the suppliers, the case company could witness lot of difference in the suppliers' treatment. Since S_1, S_2 and S_3 were highly sensitive about the abovementioned aspects, initially there was lot of defiance in awarding PCS to the case company. But, eventually there was lot of improvement along the suppliers in perceiving the manufacturer as a preferred customer.

8.6 Sectional summary

The concept of developing preferred customer relationships can be an important means for the manufacturers aspiring to have the best suppliers favorably functioning towards their requirements. Although, the preferred customer concept can tremendously influence the manufacturer-supplier relationships and advancement in manufacturing business, it has not been actively pursued both in the research and practice. Moreover, as the most of the global manufacturers have their suppliers from developing countries like India, an empirical evidence about the practice of preferred customer concept in the manufacturing environment of a developing country is vital. Thus, in this study, several aspects that can position a manufacturer as a preferred manufacturing customer for the suppliers have been empirically examined and a structural framework was established. From the empirical analysis, it was found that the manufacturers have to achieve internal stability, capability and development; practice attractive business conduct; and trigger motivational mechanisms for the suppliers in achieving PCS. Then, as the essential supply chain flows act as a must-be attribute for suppliers, the manufacturers have to ensure that this component is not overlooked. Ultimately for evolving the preferred manufacturing customer relationships, the suppliers must be collectively engaged along with the manufacturers and as a result generate mutually favorable results. Further, in order to have more pragmatic way in cultivating the preferred customer relationships, the structural framework was integrated with GTA and analyzed with reference to different case situations. The proposed process was tried in a case company and found to be useful in determining the extent to which a manufacturer can cultivate preferred customer relationships with its suppliers. Further, the manufacturer could realize its evolution as a preferred customer along the key suppliers over a period of time and could distinguish among the suppliers.

Suppliers have become the strategic partners for most of the manufacturing supply chains in order to competitively fulfill the end customers' dynamic requirements. So, most of the manufacturers are inclined to have strong and supportive supply base established and are consequently choosing to develop their suppliers to derive sustainable competitive advantages. However in conducting the SDPs, several aspects have to be systematically practiced so as to ensure definite returns on SD investments. The said aspects focused in the current research work are summarized as follows,

- Under strategic analysis of SDPs, a manufacturer is proposed to derive a strategy for successful implementation of the SDPs, strategically address the principal SDIs and timely analyze the performances of SDPs. The proposed approaches were tested in the practical case situations and were found to be of great assistance for the manufacturers. It was established that a manufacturer-supplier can systematically and concorantly conduct the SDPs as well as have the appropriate improvement strategies derived through the proposed processes.
- The concept of preferred manufacturing customer favorably positions a manufacturer in receiving the best from the suppliers. Hence, in the current study, the PCEs in general that assist a manufacturer to become a preferred customer have been analyzed. Further, a process has been proposed for measuring the PCS of a manufacturer from its key suppliers' perspectives in a specific manufacturing environment.
- Similar to the preferred customer concept, the preferred supplier concept has also been explored and examined in the current study. The PSEs that a manufacturer in general has to pursue in awarding the PSS to its key suppliers were analyzed and a process for

measuring the level of PSS along the timeline in a specific manufacturing environment has been proposed.

- Finally, the empirical analyses were conducted to draw structural frameworks for SD furtherance, to mitigate the SDIs, to cultivate preferred customer and preferred supplier relationships. The SD furtherance framework was further diagnosed and certain logical conclusions were derived for progressively implementing the SDPs. The frameworks obtained for developing the preferred customer and preferred supplier relationships were integrated with an application process which help a manufacturer to determine the extents in developing the relationships. The conclusions obtained from each empirically study are summarized as mentioned below,
    - From SD furtherance framework it was found that a manufacturer must pursue buyer-supplier understanding not beyond medium level for a better supplier development practice and reach; emphasis on a supplier's conduct and status should be at medium level (i.e. it should be neither at low level nor at high level) for a better buyer-supplier understanding; and in the Indian manufacturing environment, it was found that the buyer-supplier collaboration efforts at medium level are leading to a better buyer-supplier understanding.
    - From the path analysis of impediments to SD, it was found that a supplier's reluctance to its manufacturer's initiatives is highly influenced by the ill effects of the poor supplier's supply and demand management which in turn is highly influenced by the supplier resource incompetency under supplier side category. On a manufacturer's side category, it was found that a manufacturer's poor supplier staking was highly influenced by the lack of manufacturer's affirmation to a supplier and a manufacturer's

ineffective systems of operation leads to improper supplier selection for development and SD initiatives. Under manufacturer-supplier side category, it was found that insensitive and unreliable management systems at manufacturer-supplier leads to oppressed and limited work force. This in turn is leading to poorly connected manufacturing systems and also poor manufacturer-supplier alignment causes uncoordinated systems of resource sharing. Finally, from external environment, it was found that the unpredictability and uncertainties in the supply chains make the manufacturing systems more risk prone. While unhealthy competition and scarcity of resources cause unscrupulous internal and external agents to intervene in the systematic execution of operations and this is further magnified by uncommon and unstable regions of operation.

- From the structural framework for cultivating preferred supplier relationships, it was found that the manufacturers in Indian manufacturing environment are vastly laying emphasis on suppliers' compatibility with their manufacturing systems in ascribing preferential status. Further, the preferential support offered by the suppliers and the suppliers' initiatives for strategic alignment with the manufacturers are significantly valued. In cultivating the preferred supplier relationships, the manufacturers expect for suppliers' response to their requirements and the competence offered for the manufacturers' furtherance in the long run.
- From the structural framework for cultivating preferred customer relationships, it was found that the manufacturers have to achieve internal stability, capability and development; practice attractive business conduct; and trigger motivational mechanisms for the suppliers in achieving PCS. Then, as the essential supply chain

flows act as a must-be attribute for suppliers, the manufacturers have to ensure that this component is not overlooked. Ultimately for evolving the preferred manufacturing customer relationships, the suppliers must be collectively engaged along with the manufacturers.

Future scope of research

The current piece of research can be extended along the following research objectives,

- The current research has not considered the influence of SDEs, SDIs, PCEs and PSEs on SDOs. By applying the advanced statistical methods, the interactions among these factors and on to the SDOs may be studied.
- On the basis of current research work, the strategic fit among manufacturer-supplier can be established and in turn a manufacturer's relationship with its suppliers may be examined.
- Since the supply chain innovation has been an actively pursued subject matter, a manufacturer's SD initiatives to generate and streamline the supplier innovation flow can be a worthy contribution towards SD literature.
- The supplier risks posed on a manufacturer while conducting the SDPs can also be explored and examined to ensure the reliability of the SDPs.

References

Acharyulu, G. (2014), “Supply chain management practices in printing industry”, *Operations and Supply Chain Management*, Vol. 7 No. 2, pp. 39–45.

Adams, J.H., Khoja, F.M. and Kauffman, R. (2012), “An empirical study of buyer–supplier relationships within small business organizations”, *Journal of Small Business Management*, Wiley Online Library, Vol. 50 No. 1, pp. 20–40.

Adewuyi, A.O. and Oyejide, T.A. (2012), “Determinants of backward linkages of oil and gas industry in the Nigerian economy”, *Resources Policy*, Elsevier, Vol. 37 No. 4, pp. 452–460.

Ağan, Y., Kuzey, C., Acar, M.F. and Açıkgöz, A. (2016), “The relationships between corporate social responsibility, environmental supplier development, and firm performance”, *Journal of Cleaner Production*, Elsevier, Vol. 112, pp. 1872–1881.

Ahmed, M. and Hendry, L. (2012), “Supplier development literature review and key future research areas”, *International Journal of Engineering and Technology Innovation*, Vol. 2 No. 4, pp. 293–303.

Akamp, M. and Müller, M. (2013), “Supplier management in developing countries”, *Journal of Cleaner Production*, Vol. 56, pp. 54–62.

Albani, A. and Dietz, J.L.G. (2006), “The benefit of enterprise ontology in identifying business components”, *The Past and Future of Information Systems: 1976–2006 and Beyond*, Springer, pp. 243–254.

AlMaian, R.Y., Needy, K.L., Walsh, K.D. and Alves, T. da C.L. (2015), “Supplier Quality Management Inside and Outside the Construction Industry”, *Emj-Engineering Management Journal*, Vol. 27 No. 1, pp. 11–22.

Anand, G. and Bahinipati, B.K. (2012), “Measuring horizontal collaboration intensity in supply chain: a graph–theoretic approach”, *Production Planning & Control*, Taylor & Francis, Vol. 23 No. 10-11, pp. 801–816.

Andersen, P.H., Ellegaard, C. and Kragh, H. (2015), “I’m your man: How suppliers gain strategic status in buying companies”, *Journal of Purchasing and Supply Management*, Elsevier.

Anderson, J.C. and Gerbing, D.W. (1988), “Structural equation modeling in practice: A review and recommended two-step approach.”, *Psychological bulletin*, American Psychological Association, Vol. 103 No. 3, p. 411.

Anderson, M.G. and Katz, P.B. (1998), “Strategic sourcing”, *The International Journal of Logistics Management*, MCB UP Ltd, Vol. 9 No. 1, pp. 1–13.

Anisul Huq, Fahian, Mark Stevenson, and M.Z. (2014), “Social sustainability in developing country suppliers: An exploratory study in the ready made garments industry of Bangladesh”, *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 34 No. 5, pp. 610–638.

Antony, J., Agus, A. and Shukri Hajinoor, M. (2012), “Lean production supply chain management as driver towards enhancing product quality and business performance: Case study of manufacturing companies in Malaysia”, *International Journal of Quality & Reliability Management*, Emerald Group Publishing Limited, Vol. 29 No. 1, pp. 92–121.

Argote, L., Ingram, P., Levine, J.M. and Moreland, R.L. (2000), “Knowledge transfer in organizations: Learning from the experience of others”, *Organizational behavior and human decision processes*, Elsevier, Vol. 82 No. 1, pp. 1–8.

Arráiz, I., Henríquez, F. and Stucchi, R. (2013), “Supplier development programs and firm performance: Evidence from Chile”, *Small Business Economics*, Springer, Vol. 41 No. 1, pp. 277–293.

Arroyo-López, P., Holmen, E., Boer, L. de and Authors, F. (2012), “How do supplier development programs affect suppliers?: Insights for suppliers, buyers and governments from an empirical study in Mexico”, *Business Process Management Journal*, Vol. 18 No. 4, pp. 680–707.

Avery, S. (2008), “Suppliers follow a road map to LEAN”, *Purchasing*, Vol. 137 No. 4, pp. 53–55.

Azadegan, A. (2008), *Supplier innovativeness and manufacturer performance: an organizational learning perspective*, ProQuest.

Bai, C. and Sarkis, J. (2010), “Green supplier development: analytical evaluation using rough set theory”, *Journal of Cleaner Production*, Vol. 18 No. 12, pp. 1200–1210.

Bai, C. and Sarkis, J. (2011), “Evaluating supplier development programs with a grey based rough set methodology”, *Expert Systems with Applications*, Elsevier Ltd, Vol. 38 No. 11, pp. 13505 – 13517.

Bai, C. and Sarkis, J. (2014), “Supplier development investment strategies: a game theoretic evaluation”, *Annals of Operations Research*, Springer, pp. 1–33.

Bai, C., Sarkis, J. and Wei, X. (2010), “Addressing key sustainable supply chain management issues using rough set methodology”, *Management Research Review*, Emerald Group Publishing Limited, Vol. 33 No. 12, pp. 1113–1127.

Ballou, R.H., Gilbert, S.M. and Mukherjee, A. (2000), “New managerial challenges from supply chain opportunities”, *Industrial Marketing Management*, Elsevier, Vol. 29 No. 1, pp. 7–18.

Başaran, B. (2012), “A critique on the consistency ratios of some selected articles regarding fuzzy AHP and sustainability”, *3rd International Symposium on Sustainable Development (ISSD’12), Sarajevo*.

Bates, K., Filippini, R., Thakkar, J., Kanda, A. and Deshmukh, S.G. (2012), “Supply chain issues in Indian manufacturing SMEs: insights from six case studies”, *Journal of Manufacturing Technology Management*, Emerald Group Publishing Limited, Vol. 23 No. 5, pp. 634–664.

Baxter, R. (2012), “How can business buyers attract sellers’ resources?. Empirical evidence for preferred customer treatment from suppliers.”, *Industrial Marketing Management*, Elsevier

Inc., Vol. 41 No. 8, pp. 1249–1258.

Baxter, R. and Kleinaltenkamp, M. (2015), “How relationship conditions affect suppliers’ resource inputs”, *Australasian Marketing Journal (AMJ)*, Elsevier, Vol. 23 No. 2, pp. 117–123.

Bemelmans, J., Voordijk, H., Vos, B. and Buter, J. (2011), “Assessing buyer-supplier relationship management: Multiple case-study in the Dutch construction industry”, *Journal of construction engineering and management*, American Society of Civil Engineers, Vol. 138 No. 1, pp. 163–176.

Bemelmans, J., Voordijk, H., Vos, B. and Dewulf, G. (2015), “Antecedents and benefits of obtaining preferred customer status: Experiences from the Dutch construction industry”, *International journal of operations & production management*, Emerald Group Publishing Limited, Vol. 35 No. 2, pp. 178–200.

Bendixen, M., Bukasa, K.A. and Abratt, R. (2004), “Brand equity in the business-to-business market”, *Industrial Marketing Management*, Elsevier, Vol. 33 No. 5, pp. 371–380.

Bentler, P.M. (1990), “Comparative fit indexes in structural models.”, *Psychological bulletin*, American Psychological Association, Vol. 107 No. 2, p. 238.

Bernzen, A. (2014), “Reassessing supplier reputation in international trade coordination–a German and Australian perspective of global organic food networks”, *DIE ERDE–Journal of the Geographical Society of Berlin*, Vol. 145 No. 3, pp. 162–174.

Beske, P. and Seuring, S. (2014), “Putting sustainability into supply chain management”, *Supply Chain Management: an international journal*, Emerald Group Publishing Limited, Vol. 19 No. 3, pp. 322–331.

Bhattachrya, A.K., Coleman, J.L. and Brace, G. (1995), “Re-positioning the supplier: an SME perspective”, *Production Planning & Control*, Vol. 6 No. 3, pp. 218–226.

van Blokland, W.W.A.B., Fiksiński, M.A., Amoa, S.O.B., Santema, S.C., van Silfhout, G. and Maaskant, L. (2013), “Measuring value-leverage in aerospace supply chains”, *International Journal of Operations & Production Management*, Emerald Group Publishing Limited.

Blonska, A., Rozemeijer, F. and Wetzels, M. (2008), “The Influence of Supplier Development on Gaining a Preferential Buyer Status, Supplier Adaptation and Supplier Relational Embeddedness”, *24th IMP Conference. Uppsala*, pp. 1–19.

Blonska, A., Storey, C., Rozemeijer, F., Wetzels, M. and de Ruyter, K. (2013), “Decomposing the effect of supplier development on relationship benefits: The role of relational capital”, *Industrial Marketing Management*, Vol. 42 No. 8, pp. 1295–1306.

De Boer, L., Labro, E. and Morlacchi, P. (2001), “A review of methods supporting supplier selection”, *European Journal of Purchasing & Supply Management*, Elsevier, Vol. 7 No. 2, pp. 75–89.

Booth, C. (2014), *Strategic Procurement: Organizing suppliers and supply chains for competitive advantage*, Kogan Page Publishers.

Brashear Alejandro, T., Asare, A.K., Brashear, T.G., Yang, J. and Kang, J. (2013), "The relationship between supplier development and firm performance: the mediating role of marketing process improvement", *Journal of Business & Industrial Marketing*, Emerald Group Publishing Limited, Vol. 28 No. 6, pp. 523–532.

Brokaw, A.J. and Davisson, C.N. (1978), "'Positioning' a Company as a Preferred Customer.", *Journal of Purchasing & Materials Management*, Vol. 14 No. 1, pp. 9–11.

Browne, M.W. and Cudeck, R. (1992), "Alternative ways of assessing model fit", *Sociological Methods & Research*, Sage Publications, Vol. 21 No. 2, pp. 230–258.

Buttle, F. (1999), "The SCOPE of customer relationship management", *International Journal of Customer Relationship Management*, Vol. 1 No. 4, pp. 327–337.

Byrne, B.M. (2013), *Structural equation modeling with AMOS: Basic concepts, applications, and programming*, Routledge.

Caddick, R.J. and Dale, B.G. (1998), "The impact of total quality management on the purchasing function: influences and implications", *European Journal of Purchasing & Supply Management*, Elsevier, Vol. 4 No. 2, pp. 133–142.

Caniëls, M.C.J., Gehrsitz, M.H. and Semeijn, J. (2013), "Participation of suppliers in greening supply chains: An empirical analysis of German automotive suppliers", *Journal of Purchasing and supply management*, Elsevier, Vol. 19 No. 3, pp. 134–143.

Cannon, J.P., Doney, P.M., Mullen, M.R. and Petersen, K.J. (2010), "Building long-term orientation in buyer-supplier relationships: The moderating role of culture", *Journal of Operations Management*, Elsevier B.V., Vol. 28 No. 6, pp. 506–521.

Carr, A.S. and Kaynak, H. (2007a), "Communication methods, information sharing, supplier development and performance: An empirical study of their relationships", *International Journal of Operations and Production Management*, Vol. 27 No. 4, pp. 346 – 370.

Carr, A.S. and Kaynak, H. (2007b), "Communication methods, information sharing, supplier development and performance: An empirical study of their relationships", *International Journal of Operations & Production Management*, Vol. 27 No. 4, pp. 346–370.

Carr, A.S., Kaynak, H., Hartley, J.L. and Ross, A. (2008), "Supplier dependence: impact on supplier's participation and performance", *International Journal of Operations & Production Management*, Vol. 28 No. 9, pp. 899–916.

Carr, A.S. and Pearson, J.N. (1999), "Strategically managed buyer–supplier relationships and performance outcomes", *Journal of operations management*, Elsevier, Vol. 17 No. 5, pp. 497–519.

Carter, C.R. (2000), "Ethical issues in international buyer-supplier relationships: A dyadic examination", *Journal of Operations Management*, Vol. 18 No. 2, pp. 191–208.

Carter, J.R., Slaight, T.H. and Blascovich, J.D. (2007), "Technology, collaboration, supply chain design", *Supply chain management review*, p. 45.

Carvalho, H., Cruz-Machado, V. and Tavares, J.G. (2012), "A mapping framework for assessing Supply Chain resilience", *International Journal of Logistics Systems and Management*, Inderscience, Vol. 12 No. 3, pp. 354–373.

Chakravarty, A.K. (2014), "Managing Suppliers", *Supply Chain Transformation*, Springer, pp. 89–128.

Chan, K., Charles, A., Young, K., Hahn, C.K., Watts, C.A. and Kim, K.Y. (1990), "The supplier development program: a conceptual model", *Journal of Purchasing and Materials Management*, Vol. 26 No. 2, pp. 2–7.

Chang, B., Chang, C. and Wu, C. (2011), "Fuzzy DEMATEL method for developing supplier selection criteria", *Expert Systems with Applications*, Elsevier, Vol. 38 No. 3, pp. 1850–1858.

Chang, D.-Y. (1996), "Applications of the extent analysis method on fuzzy AHP", *European journal of operational research*, Elsevier, Vol. 95 No. 3, pp. 649–655.

Chavhan, R., Mahajan, S.K. and Sarang, J. (2012), "Supplier development: theories and practices", *IOSR Journal of Mechanical and Civil Engineering*, Vol. 3 No. 3.

Chen, L., Ellis, S.C. and Holsapple, C.W. (2011), "A Knowledge-sharing Perspective on Supplier Development Activities.", *AMCIS 2011 Proceedings*, available at: http://aisel.aisnet.org/amcis2011_submissions/3.

Chen, P.-S. and Wu, M.-T. (2013), "A modified failure mode and effects analysis method for supplier selection problems in the supply chain risk environment: A case study", *Computers & Industrial Engineering*, Elsevier Ltd, Vol. 66 No. 4, pp. 634–642.

Chiang, C.-Y., Kocabasoglu-Hillmer, C. and Suresh, N. (2012), "An empirical investigation of the impact of strategic sourcing and flexibility on firm's supply chain agility", *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 32 No. 1, pp. 49–78.

Chidambaranathan, S., Muralidharan, C. and Deshmukh, S.G. (2009), "Analyzing the interaction of critical factors of supplier development using Interpretive Structural Modeling—an empirical study", *The International Journal of Advanced Manufacturing Technology*, Springer, Vol. 43 No. 11-12, pp. 1081–1093.

Choi, T.Y., Dooley, K.J. and Rungtusanatham, M. (2001), "Supply networks and complex adaptive systems: control versus emergence", *Journal of operations management*, Elsevier, Vol. 19 No. 3, pp. 351–366.

Chopra, S. and Meindl, P. (2007), *Supply chain management. Strategy, planning & operation*, Springer.

Choy, K.L., Lee, W.B., Lau, H.C.W. and Choy, L.C. (2005), "A knowledge-based supplier intelligence retrieval system for outsource manufacturing", *Knowledge-based systems*, Elsevier, Vol. 18 No. 1, pp. 1–17.

Christiansen, P.E. and Maltz, A. (2002), "Becoming an‘ interesting' customer: Procurement strategies for buyers without leverage", *International Journal of Logistics*, Taylor & Francis, Vol. 5 No. 2, pp. 177–195.

Christopher, M. (1996), "From brand values to customer value", *Journal of Marketing Practice: applied marketing science*, MCB UP Ltd, Vol. 2 No. 1, pp. 55–66.

Closs, D.J. and Mollenkopf, D.A. (2004), "A global supply chain framework", *Industrial Marketing Management*, Elsevier, Vol. 33 No. 1, pp. 37–44.

Connelly, B.L., Ketchen, D.J. and Hult, G.T.M. (2013), "Global supply chain management: toward a theoretically driven research agenda", *Global Strategy Journal*, Wiley Online Library, Vol. 3 No. 3, pp. 227–243.

Corbett, C.J., Blackburn, J.D. and Van Wassenhove, L.N. (2012), "Partnerships to improve supply chains", *Sloan Management*.

Cordón, C. and Vollmann, T.E. (2008), *The Power of Two: How Smart Companies Create Win: Win Customer-Supplier Partnerships that Outperform the Competition*, Palgrave Macmillan.

Costantino, N. and Pellegrino, R. (2010), "Choosing between single and multiple sourcing based on supplier default risk: A real options approach", *Journal of Purchasing and Supply Management*, Elsevier, Vol. 16 No. 1, pp. 27–40.

Cousins, P.D., Lawson, B., Petersen, K.J. and Handfield, R.B. (2011), "Breakthrough scanning, supplier knowledge exchange, and new product development performance", *Journal of Product Innovation Management*, Wiley Online Library, Vol. 28 No. 6, pp. 930–942.

Cox, A. (2001), "Managing with power: strategies for improving value appropriation from supply relationships", *Journal of Supply Chain Management*, Vol. 37 No. 2, pp. 42–47.

Cox, A. (2004), "Business relationship alignment: on the commensurability of value capture and mutuality in buyer and supplier exchange", *Supply Chain Management: An International Journal*, Emerald Group Publishing Limited, Vol. 9 No. 5, pp. 410–420.

Cox, A. and Thompson, I. (1997), "'Fit for purpose'contractual relations: determining a theoretical framework for construction projects", *European journal of purchasing & supply management*, Elsevier, Vol. 3 No. 3, pp. 127–135.

Crosno, J.L., Dahlstrom, R. and Manolis, C. (2015), "Comply or defy? An empirical investigation of change requests in buyer-supplier relationships", *Journal of Business & Industrial Marketing*, Emerald Group Publishing Limited, Vol. 30 No. 5, pp. 688–699.

Dahwa, M.P., Al-Hakim, L. and Ng, E. (2013), "The Importance of Trust in Procurement Practices and Its Impact on Business Performance: An Empirical Investigation From the Perspective of the Buyer–Supplier Dyad", *Journal of Relationship Marketing*, Taylor & Francis, Vol. 12 No. 4, pp. 280–300.

Le Dain, M., Calvi, R. and Cheriti, S. (2011), "Measuring supplier performance in collaborative design: proposition of a framework", *R&d Management*, Wiley Online Library, Vol. 41 No. 1, pp. 61–79.

Danese, P. (2013), "Supplier integration and company performance: a configurational view", *Omega*, Elsevier, Vol. 41 No. 6, pp. 1029–1041.

Danese, P., Romano, P. and Formentini, M. (2013), "The impact of supply chain integration on responsiveness: The moderating effect of using an international supplier network", *Transportation Research Part E: Logistics and Transportation Review*, Elsevier, Vol. 49 No. 1, pp. 125–140.

Dedhia, N.S. (1990), "Supplier partnership program", *Total Quality Management*, Taylor & Francis, Vol. 1 No. 3, pp. 327–334.

Dekker, H.C., Sakaguchi, J. and Kawai, T. (2013), "Beyond the contract: Managing risk in supply chain relations", *Management Accounting Research*, Elsevier, Vol. 24 No. 2, pp. 122–139.

Delaney, A., Burchielli, R. and Connor, T. (2015), "Positioning women homeworkers in a global footwear production network: How can homeworkers improve agency, influence and claim rights?", *Journal of Industrial Relations*, SAGE Publications, Vol. 57 No. 4, pp. 641–659.

Delmas, M. and Montiel, I. (2009), "Greening the supply chain: When is customer pressure effective?", *Journal of Economics and Management Strategy*, Vol. 18 No. 1, pp. 171–201.

Deshmukh, A.J. and Vasudevan, H. (2014), "Emerging supplier selection criteria in the context of traditional vs green supply chain management", *International Journal of Managing Value and Supply Chains*, Vol. 5 No. 1, pp. 19–33.

Dharmadhikari, S. (2012), "Eco-Friendly Packaging in Supply Chain", *IUP Journal of Supply Chain Management*, IUP Publications, Vol. 9 No. 2, p. 7.

Dogan, I. and Aydin, N. (2011), "Combining Bayesian Networks and Total Cost of Ownership method for supplier selection analysis", *Computers & Industrial Engineering*, Elsevier, Vol. 61 No. 4, pp. 1072–1085.

Doha, A., Das, A. and Pagell, M. (2013), "The influence of product life cycle on the efficacy of purchasing practices", *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 33 No. 4, pp. 470–498.

Dorsch, M.J., Swanson, S.R. and Kelley, S.W. (1998a), "The Role of Relationship Quality in the Stratification of Vendors as Perceived by Customers", *Journal of the Academy of Marketing Science*, Sage Publications, Vol. 26 No. 2, pp. 128–142.

Dorsch, M.J., Swanson, S.R. and Kelley, S.W. (1998b), "The Role of Relationship Quality in the Stratification of Vendors as Perceived by Customers", *Journal of the Academy of Marketing Science*, Vol. 26 No. 2, pp. 128–142.

Dou, Y., Zhu, Q. and Sarkis, J. (2014a), "Evaluating green supplier development programs with a grey-analytical network process-based methodology", *European Journal of Operational Research*, Elsevier, Vol. 233 No. 2, pp. 420–431.

Dou, Y., Zhu, Q. and Sarkis, J. (2014b), "Integrating Strategic Carbon Management into Formal Evaluation of Environmental Supplier Development Programs", *Business Strategy and the*

Environment, Wiley Online Library, p. n/a–n/a.

Dries, L., Germenji, E., Noev, N. and Swinnen, J.F.M. (2009), "Farmers, vertical coordination, and the restructuring of dairy supply chains in Central and Eastern Europe", *World development*, Elsevier, Vol. 37 No. 11, pp. 1742–1758.

Dries, L., Gorton, M., Urutyan, V. and White, J. (2014), "Supply chain relationships, supplier support programmes and stimulating investment: evidence from the Armenian dairy sector", *Supply Chain Management: An International Journal*, Emerald Group Publishing Limited, Vol. 19 No. 1, pp. 98–107.

Duffy, R., Fearne, A., Hornibrook, S., Hutchinson, K. and Reid, A. (2013), "Engaging suppliers in CRM: The role of justice in buyer–supplier relationships", *International Journal of Information Management*, Elsevier, Vol. 33 No. 1, pp. 20–27.

Dunn, S.C. and Young, R.R. (2004), "Supplier Assistance Within Supplier Development Initiatives", *The Journal of Supply Chain Management*, Vol. 40, pp. 19–29.

Dyer, J.H. and Nobeoka, K. (2000), "Creating and managing a high-performance knowledge-sharing network: the Toyota case", *Strategic management journal*, JSTOR, Vol. 21 No. 3, pp. 345–367.

Ecel, A., Ntayi, J. and Ngoma, M. (2013), "Supplier development and export performance of oil-seed agro-processing firms in Uganda", *European Scientific Journal*, Vol. 9 No. 13, pp. 469–491.

Egels-Zandén, N. (2014), "Revisiting supplier compliance with MNC codes of conduct: Recoupling policy and practice at Chinese toy suppliers", *Journal of Business Ethics*, Springer, Vol. 119 No. 1, pp. 59–75.

Ehrgott, M., Reimann, F., Kaufmann, L. and Carter, C.R. (2013), "Environmental development of emerging economy suppliers: antecedents and outcomes", *Journal of Business Logistics*, Wiley Online Library, Vol. 34 No. 2, pp. 131–147.

Ellegaard, C., Johansen, J. and Drejer, A. (2003), "Managing industrial buyer-supplier relations-the case for attractiveness", *Integrated Manufacturing Systems*, MCB UP Ltd, Vol. 14 No. 4, pp. 346–356.

Ellegaard, C. and Koch, C. (2012), "The effects of low internal integration between purchasing and operations on suppliers' resource mobilization", *Journal of Purchasing and Supply Management*, Elsevier, Vol. 18 No. 3, pp. 148–158.

Ellegaard, C. and Ritter, T. (2007), "Attractiveness in business markets: conceptualization and propositions", *White paper*.

Ellis, S.C., Henke, J.W. and Kull, T.J. (2012), "The effect of buyer behaviors on preferred customer status and access to supplier technological innovation: An empirical study of supplier perceptions", *Industrial Marketing Management*, Elsevier, Vol. 41 No. 8, pp. 1259–1269.

Ellram, L.M., Tate, W.L. and Feitzinger, E.G. (2013), “Factor-Market Rivalry and Competition for Supply Chain Resources”, *Journal of Supply Chain Management*, Wiley Online Library, Vol. 49 No. 1, pp. 29–46.

Emiliani, M.L. (2003), “The inevitability of conflict between buyers and sellers”, *Supply Chain Management: An International Journal*, MCB UP Ltd, Vol. 8 No. 2, pp. 107–115.

Emiliani, M.L. (2010), “Historical lessons in purchasing and supplier relationship management”, *Journal of Management History*, Emerald Group Publishing Limited, Vol. 16 No. 1, pp. 116–136.

Erdem, A.S. and Göçen, E. (2012), “Development of a decision support system for supplier evaluation and order allocation”, *Expert Systems with Applications*, Elsevier, Vol. 39 No. 5, pp. 4927–4937.

Erkul, M., Kaynak, H. and Montiel, I. (2015), “Supplier relations and sustainable operations: the roles of codes of conduct and human resource development”, *International Journal of Integrated Supply Management*, Inderscience Publishers, Vol. 9 No. 3, pp. 225–249.

Esteves, A.M. and Ivanova, G. (2013), “Using Social and Economic Impact Assessment to guide local supplier development initiatives”, *Handbook of Research Methods and Applications in Economic Geography, forthcoming*.

Van Everdingen, Y., Van Hillegersberg, J. and Waarts, E. (2000), “Enterprise resource planning: ERP adoption by European midsize companies”, *Communications of the ACM*, ACM, Vol. 43 No. 4, pp. 27–31.

EY. (2015), “EY’s 2015 India attractiveness survey”.

Fawcett, S.E., Jones, S.L. and Fawcett, A.M. (2012), “Supply chain trust: the catalyst for collaborative innovation”, *Business Horizons*, Elsevier, Vol. 55 No. 2, pp. 163–178.

Fawcett, S.E., Magnan, G.M. and Ogden, J.A. (2007), “Achieving world-class supply chain collaboration: Managing the transformation”, *Institute for Supply Management, Tempe, AZ*.

Fawcett, S.E. and Waller, M.A. (2013), “Considering Supply Chain Management’s Professional Identity: The Beautiful Discipline (Or,‘We Don’t Cure Cancer, But We Do Make a Big Difference’)”, *Journal of Business Logistics*, Wiley Online Library, Vol. 34 No. 3, pp. 183–188.

Feldman, L.J. (1998), “Industry viewpoint: relational interdependency and punctuated equilibrium”, *Journal of Business & Industrial Marketing*, MCB UP Ltd, Vol. 13 No. 3, pp. 288–293.

Fontela, E. and Gabus, A. (1974a), *DEMATEL, innovative methods*, Report.

Fontela, E. and Gabus, A. (1974b), “DEMATEL: Progress achieved”, *Futures*, Pergamon, Vol. 6 No. 4, pp. 361–363.

Forker, L.B. and Stannack, P. (2000), “Cooperation versus competition: do buyers and suppliers really see eye-to-eye?”, *European Journal of Purchasing & Supply Management*, Vol. 6 No. 1, pp. 31–40.

Friedl, G. and Wagner, S.M. (2012), “Supplier development or supplier switching?”, *International Journal of Production Research*, Taylor & Francis, Vol. 50 No. 11, pp. 3066–3079.

Fu, X., Zhu, Q. and Sarkis, J. (2012), “Evaluating green supplier development programs at a telecommunications systems provider”, *International Journal of Production Economics*, Elsevier, Vol. 140 No. 1, pp. 357–367.

Fynes, B. and Voss, C. (2002), “The moderating effect of buyer-supplier relationships on quality practices and performance”, *International Journal of Operations & Production Management*, MCB UP Ltd, Vol. 22 No. 6, pp. 589–613.

Gadde, L.-E. and Snehota, I. (2000), “Making the most of supplier relationships”, *Industrial Marketing Management*, Elsevier, Vol. 29 No. 4, pp. 305–316.

Galt, J.D.A. and Dale, B.G. (1991), “Supplier Development : A British Case Study”, *International Journal of Purchasing and Materials Management*, Vol. 27 No. 1, pp. 16–22.

Gaskin, J. (2012), “Structural equation modeling”, *Gaskination’s StatWiki. http://statwiki. kolobkreations. com*.

Gassenheimer, J.B., Calantone, R.J. and Scully, J.I. (1995), “Supplier involvement and dealer satisfaction: implications for enhancing channel relationships”, *Journal of Business & Industrial Marketing*, Vol. 10 No. 2, pp. 7–19.

Gathering, S., Wynstra, F., Anderson, J.C., Narus, J.A. and Wouters, M. (2012), “Supplier Development Responsibility and NPD Project Outcomes: The Roles of Monetary Quantification of Differences and Supporting-Detail Gathering”, *Journal of Product Innovation Management*, Vol. 29, pp. 103–123.

Ghijsen, P.W.T.T., Semeijn, J. and Ernstson, S. (2010), “Supplier satisfaction and commitment : The role of influence strategies and supplier development”, *Journal of Purchasing and Supply Management*, Elsevier, Vol. 16 No. 1, pp. 17–26.

Giannakis, M. (2008), “Facilitating learning and knowledge transfer through supplier development”, *Supply Chain Management: An International Journal*, Emerald Group Publishing Limited, Vol. 13 No. 1, pp. 62–72.

Gil, N. (2009), “Developing Cooperative project client-supplier relationships: How much to expect from relational contracts”, *California Management Review*, University of California Walter A. Haas School of Business, Vol. 51 No. 2, pp. 144–169.

Goedhuys, M. and Sleuwaegen, L. (2013), “The impact of international standards certification on the performance of firms in less developed countries”, *World Development*, Elsevier, Vol. 47, pp. 87–101.

Gosling, J., Naim, M., Towill, D., Abouarghoub, W. and Moone, B. (2015), “Supplier development initiatives and their impact on the consistency of project performance”, *Construction Management and Economics*, No. June 2015, pp. 1–14.

Gosling, J., Purvis, L. and Naim, M.M. (2010a), "Supply chain flexibility as a determinant of supplier selection", *International Journal of Production Economics*, Elsevier, Vol. 128 No. 1, pp. 11–21.

Gosling, J., Purvis, L. and Naim, M.M. (2010b), "Supply chain flexibility as a determinant of supplier selection", *International Journal of Production Economics*, Vol. 128 No. 1, pp. 11–21.

Gotzamani, K.D. and Theodorakioglou, Y.D. (2010), "Critical barriers to the implementation of close supplier–buyer relationships: the case of Greek manufacturing industry", *International Journal of Logistics: Research and Applications*, Taylor & Francis, Vol. 13 No. 3, pp. 211–224.

Govindan, K., Kannan, D., Haq, A.N. and Noorul Haq, A. (2010), "Analyzing supplier development criteria for an automobile industry", *Industrial Management & Data Systems*, Emerald Group Publishing Limited, Vol. 110 No. 1, pp. 43–62.

Govindarajan, V. and Trimble, C. (2012), "Reverse innovation: a global growth strategy that could pre-empt disruption at home", *Strategy & Leadership*, Emerald Group Publishing Limited, Vol. 40 No. 5, pp. 5–11.

Graebner, M.E., Eisenhardt, K.M. and Roundy, P.T. (2010), "Success and failure in technology acquisitions: Lessons for buyers and sellers", *The Academy of Management Perspectives*, Academy of Management, Vol. 24 No. 3, pp. 73–92.

Granman, T. and Helgosson, M. (2013), *Succeeding in supplier development: a qualitative case study of scania cv ab suppliers*, Linköping, Linköping University, The Institute of Technology, available at: urn:nbn:se:liu:diva-86961.

Grimm, J.H., Hofstetter, J.S. and Sarkis, J. (2012), "Understanding diffusion of corporate sustainability standards through sub-supplier management in the food supply chain", *George Perkins Marsh Institute, Worcester*.

Grimm, J.H., Hofstetter, J.S. and Sarkis, J. (2014), "Critical factors for sub-supplier management: A sustainable food supply chains perspective", *International Journal of Production Economics*, Elsevier, Vol. 152, pp. 159–173.

Grover, S., Agrawal, V.P. and Khan, I.A. (2005), "Human resource performance index in TQM environment", *International Journal of Management Practice*, Inderscience Publishers, Vol. 1 No. 2, pp. 131–151.

Gupta, M. and Narain, R. (2012), "A survey on supplier relationship in e-procurement in Indian organisations", *International Journal of Logistics Systems and Management*, Inderscience, Vol. 12 No. 1, pp. 89–121.

Gupta, S. and Kim, H.W. (2008), "Linking structural equation modeling to Bayesian networks : Decision support for customer retention in virtual communities", Vol. 190, pp. 818–833.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E. and Tatham, R.L. (2006), *Multivariate data analysis*, Pearson Prentice Hall Upper Saddle River, NJ, Vol. 6.

Hald, K.S., Cordón, C. and Vollmann, T.E. (2009), "Towards an understanding of attraction in buyer–supplier relationships", *Industrial Marketing Management*, Elsevier, Vol. 38 No. 8, pp. 960–970.

Halley, A. and Nollet, J. (2002), "The supply chain: The weak link for some preferred suppliers?", *Journal of Supply Chain Management*, Vol. 38 No. 3, pp. 39–47.

Hallikas, J., Karvonen, I., Pulkkinen, U., Virolainen, V.-M. and Tuominen, M. (2004), "Risk management processes in supplier networks", *International Journal of Production Economics*, Elsevier, Vol. 90 No. 1, pp. 47–58.

Hammervoll, T. (2012), "Managing interaction for learning and value creation in exchange relationships", *Journal of Business Research*, Elsevier, Vol. 65 No. 2, pp. 128–136.

Han, S.-L., Sung, H.-S. and Shim, H.-S. (2014), "Antecedents and performance outcomes of flexibility in industrial customer–supplier relationships", *Journal of Business Research*, Elsevier, Vol. 67 No. 10, pp. 2115–2122.

Handfield, R., Walton, S. V., Sroufe, R. and Melnyk, S. a. (2002), "Applying environmental criteria to supplier assessment: A study in the application of the Analytical Hierarchy Process", *European Journal of Operational Research*, Vol. 141 No. 1, pp. 70–87.

Handfield, R.B., Cousins, P.D., Lawson, B. and Petersen, K.J. (2014), "How Can Supply Management Really Improve Performance? A Knowledge-Based Model of Alignment Capabilities", *Journal of Supply Chain Management*, Wiley Online Library.

Handfield, R.B., Krause, D.R., Scannell, T. V and Monczka, R.M. (2000), "Avoid the pitfalls in supplier development", *Sloan Management Review*, Vol. 41 No. 2, pp. 37–49.

Handfield, R.B., Krause, D.R., Scannell, T. V and Monczka, R.M. (2006), "Avoid the pitfalls in supplier development", *Supply Chains and Total Product Systems: A Reader*, Vol. 58.

Hartley, J. and Jones, G. (1997), "Process oriented supplier development: building the capability for change", *International Journal of Purchasing and Materials Management*, No. August, pp. 24–29.

Hartmann, J. and Moeller, S. (2014), "Chain liability in multitier supply chains? Responsibility attributions for unsustainable supplier behavior", *Journal of Operations Management*, Elsevier B.V., Vol. 32 No. 5, pp. 281–294.

Hawes, J., Baker, T.L. and d'Amico, M.F. (2006), "A purchasing perspective of the universal marketing functions", *Journal of Marketing Management*, Vol. 16 No. 2, pp. 107–115.

Heikkurinen, P. (2010), "Image differentiation with corporate environmental responsibility", *Corporate social responsibility and environmental management*, Wiley Online Library, Vol. 17 No. 3, pp. 142–152.

Heilmann, P., Lintukangas, K. and Peltola, S. (2011), "Competence areas and knowledge gaps in supply management", *International Journal of Procurement Management*, Inderscience Publishers, Vol. 4 No. 6, pp. 642–660.

Herbig, P. and O'Hara, B. (1996), "International procurement practices: a matter of relationships", *Management Decision*, Vol. 34 No. 4, pp. 41–45.

Herrigel, G. (2004), "Emerging strategies and forms of governance in high-wage component manufacturing regions", *Industry and Innovation*, Taylor & Francis, Vol. 11 No. 1-2, pp. 45–79.

Hesping, F.H. and Schiele, H. (2015), "Purchasing strategy development: A multi-level review", *Journal of purchasing and supply management*, Elsevier, Vol. 21 No. 2, pp. 138–150.

Hingley, M., Lindgreen, A. and Grant, D.B. (2015), "Intermediaries in power-laden retail supply chains: An opportunity to improve buyer–supplier relationships and collaboration", *Industrial Marketing Management*, Elsevier.

Ho, H. and Ganesan, S. (2013), "Does knowledge base compatibility help or hurt knowledge sharing between suppliers in coopetition? The role of customer participation", *Journal of Marketing*, American Marketing Association, Vol. 77 No. 6, pp. 91–107.

Hock Soon, Q. and Mohamed Udin, Z. (2011), "Supply chain management from the perspective of value chain flexibility: an exploratory study", *Journal of Manufacturing Technology Management*, Emerald Group Publishing Limited, Vol. 22 No. 4, pp. 506–526.

Hoejmose, S., Brammer, S. and Millington, A. (2013), "An empirical examination of the relationship between business strategy and socially responsible supply chain management", *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 33 No. 5, pp. 589–621.

Hoffmann, P., Schiele, H. and Krabbendam, K. (2013), "Uncertainty, supply risk management and their impact on performance", *Journal of purchasing and supply management*, Elsevier, Vol. 19 No. 3, pp. 199–211.

Hofmann, E., Beck, P. and Füger, E. (2013), "CM3: Supplier Segmentation and Supply Strategy", *The Supply Chain Differentiation Guide*, Springer, pp. 107–123.

Holmen, E. and Kristensen, P.S. (1998), "Supplier roles in product development: Interaction versus task partitioning", *European Journal of Purchasing & Supply Management*, Elsevier, Vol. 4 No. 2, pp. 185–193.

Hori, S. and Shimizu, Y. (1999), "Designing methods of human interface for supervisory control systems", *Control Engineering Practice*, Elsevier, Vol. 7 No. 11, pp. 1413–1419.

Horn, P., Scheffler, P. and Schiele, H. (2014), "Internal integration as a pre-condition for external integration in global sourcing: A social capital perspective", *International journal of production economics*, Elsevier, Vol. 153, pp. 54–65.

Hottenstein, M.P. (1970), "Expediting in job-order-control systems: a simulation study", *AIIE*

Transactions, Taylor & Francis, Vol. 2 No. 1, pp. 46–54.

Hsiao, S.-W. and Ko, Y.-C. (2013), "A study on bicycle appearance preference by using FCE and FAHP", *International Journal of Industrial Ergonomics*, Elsevier, Vol. 43 No. 4, pp. 264–273.

Hu, L. and Bentler, P.M. (1999), "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives", *Structural equation modeling: a multidisciplinary journal*, Taylor & Francis, Vol. 6 No. 1, pp. 1–55.

Hu, X., Gurnani, H. and Wang, L. (2013), "Managing risk of supply disruptions: Incentives for capacity restoration", *Production and Operations Management*, Wiley Online Library, Vol. 22 No. 1, pp. 137–150.

Humphreys, P., Cadden, T., Wen-li, L. and McHugh, M. (2011), "An investigation into supplier development activities and their influence on performance in the Chinese electronics industry", *Production Planning & Control*, Vol. 22 No. 2, pp. 137–156.

Hüttinger, L. (2014), *Preferential customer treatment by suppliers - Identifying benefits and antecedents*, Universiteit Twente, available at: http://doc.utwente.nl/89869/.

Hüttinger, L., Schiele, H. and Veldman, J. (2012), "The drivers of customer attractiveness, supplier satisfaction and preferred customer status: A literature review", *Industrial Marketing Management*, Elsevier B.V., Vol. 41 No. 8, pp. 1194–1205.

Inemek, A. and Matthyssens, P. (2013), "The impact of buyer–supplier relationships on supplier innovativeness: An empirical study in cross-border supply networks", *Industrial Marketing Management*, Elsevier, Vol. 42 No. 4, pp. 580–594.

Ireland, P. (2004), "Managing appropriately in construction power regimes: understanding the impact of regularity in the project environment", *Supply Chain Management: An International Journal*, Emerald Group Publishing Limited, Vol. 9 No. 5, pp. 372–382.

Ivarsson, I. and Alvstam, C.G. (2010), "Upgrading in global value-chains: a case study of technology-learning among IKEA-suppliers in China and Southeast Asia", *Journal of Economic Geography*, Oxford Univ Press, p. lbq009.

Ivens, B.S., Van de Vijver, M. and Vos, B. (2013), "Managing and developing key supplier relationships: An introduction to the special issue, discussion and implications", *Industrial Marketing Management*, Elsevier, Vol. 42 No. 2, pp. 135–138.

Iyer, G.R., LaPlaca, P.J. and Sharma, A. (2006), "Innovation and new product introductions in emerging markets: Strategic recommendations for the Indian market", *Industrial Marketing Management*, Elsevier, Vol. 35 No. 3, pp. 373–382.

Jacobsen, J. (2011), "The quality professional's role in ISO 26000", *The Journal for Quality and Participation*, American Society for Quality, Vol. 34 No. 1, p. 21.

Jain, S.K. and Singh Ahuja, I. (2012), "An evaluation of ISO 9000 initiatives in Indian industry for enhanced manufacturing performance", *International Journal of Productivity and*

Performance Management, Emerald Group Publishing Limited, Vol. 61 No. 7, pp. 778–804.

Janssens, W., Wijnen, K., De Pelsmacker, P. and Van Kenhove, P. (2008), *Marketing research with SPSS*, Pearson.

Jin, Y., Vonderembse, M., Ragu-Nathan, T.S. and Smith, J.T. (2014), "Exploring relationships among IT-enabled sharing capability, supply chain flexibility, and competitive performance", *International Journal of Production Economics*, Elsevier, Vol. 153, pp. 24–34.

Johansson, J.K. and Ronkainen, I.A. (2005), "The esteem of global brands", *The Journal of Brand Management*, Palgrave Macmillan, Vol. 12 No. 5, pp. 339–354.

Johnson, A.S., Wyatt, C.M. and Evans, S. (1998), "Performance measurement and relationship management in the automotive supply chain", *Strategic Management of the Manufacturing Value Chain*, Springer, pp. 209–216.

Johnson, J.G. (1992), "Building supplier partnerships", *The Journal for Quality and Participation*, Vol. 15 No. 1, pp. 14–18.

Jones, S. (2008), "Corporate payments: opportunities for value-added services to be offered alongside payment products", *Journal of Payments Strategy & Systems*, Henry Stewart, Vol. 2 No. 4, pp. 392–399.

Joo, S.-J., Messer Jr, G.H. and Bradshaw, R. (2009), "The performance evaluation of existing suppliers using data envelopment analysis", *International Journal of Services and Operations Management*, Inderscience Publishers, Vol. 5 No. 4, pp. 429–443.

Ju-Long, D. (1982), "Control problems of grey systems", *Systems & Control Letters*, Elsevier, Vol. 1 No. 5, pp. 288–294.

Jutla, D., Craig, J. and Bodorik, P. (2001), "Enabling and measuring electronic customer relationship management readiness", *System Sciences, 2001. Proceedings of the 34th Annual Hawaii International Conference on*, IEEE, p. 10–pp.

Kähkönen, A.-K., Lintukangas, K., Hallikas, J. and Wagner, B. (2015), "Buyer's dependence in value creating supplier relationships", *Supply Chain Management: An International Journal*, Emerald Group Publishing Limited, Vol. 20 No. 2.

Kahraman, C., Cebeci, U. and Ulukan, Z. (2003), "Multi-criteria supplier selection using fuzzy AHP", *Logistics information management*, MCB UP Ltd, Vol. 16 No. 6, pp. 382–394.

Kaipia, R. and Tanskanen, K. (2003), "Vendor managed category management—an outsourcing solution in retailing", *Journal of Purchasing and Supply Management*, Elsevier, Vol. 9 No. 4, pp. 165–175.

Kanda, A. and Deshmukh, S.G. (2008), "Supply chain coordination: perspectives, empirical studies and research directions", *International journal of production Economics*, Elsevier, Vol. 115 No. 2, pp. 316–335.

Kandasamy, W.B.V., Smarandache, F. and Ilanthenral, K. (2007), *Elementary fuzzy matrix theory* *and fuzzy models for social scientists*, Automation, Los Angeles.

Kaplinsky, R. (2014), “Shudder: The challenges to ‘industrial policies’ in the early 21st century in low-and middle-income economies”, *International Business and Sustainable Development (Progress in International Business Research, Volume 8) Emerald Group Publishing Limited*, Vol. 8, pp. 69–90.

Khan K, A. and Pillania, R.K. (2008), “Strategic sourcing for supply chain agility and firms’ performance: A study of Indian manufacturing sector”, *Management Decision*, Emerald Group Publishing Limited, Vol. 46 No. 10, pp. 1508–1530.

Kihara, R.M. and Ngugi, G.K. (2013), “Role of procurement planning on performance: A case at Nyayo Tea Zones Development Corporation”, *International Journal of Social Sciences and Entrepreneurship*, Vol. 1 No. 5, pp. 714–727.

Kim, B.Y. (2006), “The Impact of Supplier Development on Financial Performance in the Restaurant Industry”, *International Journal of Hospitality & Tourism Administration,* Vol. 7 No. 4, pp. 81–103.

Kim, K.K., Park, S.-H., Ryoo, S.Y. and Park, S.K. (2010), “Inter-organizational cooperation in buyer–supplier relationships: Both perspectives”, *Journal of Business Research*, Elsevier, Vol. 63 No. 8, pp. 863–869.

Klassen, R.D. and Vachon, S. (2003), “Collaboration and evaluation in the supply chain: The impact on plant-level environmental investment”, *Production and Operations Management*, Wiley Online Library, Vol. 12 No. 3, pp. 336–352.

Kokkonen, P. and Tuohino, A. (2007), “The challenge of networking: analysis of innovation potential in small and medium-sized tourism enterprises”, *The International Journal of Entrepreneurship and Innovation*, IP Publishing Ltd, Vol. 8 No. 1, pp. 44–52.

Kossovsky, N. (2012), *Reputation, Stock Price, and You: Why the Market Rewards Some Companies and Punishes Others*, Apress.

Kotula, M., Ho, W., Dey, P.K. and Lee, C.K.M. (2015), “Strategic sourcing supplier selection misalignment with critical success factors: Findings from multiple case studies in Germany and the united kingdom”, *International Journal of Production Economics*, Elsevier.

Koufteros, X., Vickery, S.K. and Dröge, C. (2012), “The Effects of Strategic Supplier Selection on Buyer Competitive Performance in Matched Domains: Does Supplier Integration Mediate the Relationships?”, *Journal of Supply Chain Management*, Vol. 48 No. 2, pp. 93–115.

KPMG. (2014), “FUTUREBUY : The Future of Procurement”, No. February, pp. 1–20.

Krause, D. and Ellram, L.M. (2014), “The Effects of the Economic Downturn on Interdependent Buyer–Supplier Relationships”, *Journal of Business Logistics*, Wiley Online Library, Vol. 35 No. 3, pp. 191–212.

Krause, D.R. (1997), “Supplier Development: Current Practices and Outcomes”, *International Journal of Purchasing and Materials Management*, Vol. 33 No. 1, pp. 12–19.

Krause, D.R. (1999), "The antecedents of buying firms' efforts to improve suppliers", *Journal of Operations Management*, Vol. 17 No. 2, pp. 205–224.

Krause, D.R. and Ellram, L.M. (1997a), "Critical elements of supplier development The buying-firm perspective", *European Journal of Purchasing & Supply Management*, Vol. 3 No. 1, pp. 21–31.

Krause, D.R. and Ellram, L.M. (1997b), "Success factors in supplier development", *International Journal of Physical Distribution & Logistics Management*, Vol. 27 No. 1, pp. 39–52.

Krause, D.R., Handfield, R.B. and Scannell, T. V. (1998), "An empirical investigation of supplier development: reactive and strategic processes", *Journal of Operations Management*, Vol. 17 No. 1, pp. 39–58.

Krause, D.R., Handfield, R.B. and Tyler, B.B. (2007), "The relationships between supplier development, commitment, social capital accumulation and performance improvement", *Journal of Operations Management*, Vol. 25 No. 2, pp. 528–545.

Krause, D.R. and Scannell, T. V. (2002a), "Supplier Development Practices ":, *Journal of Supply Chain Management*, Vol. 38 No. 1, pp. 13–21.

Krause, D.R., Scannell, T. V and Calantone, R.J. (2000), "A structural analysis of the effectiveness of buying firms' strategies to improve supplier performance", *Decision Sciences*, American Institute for Decision Sciences, Vol. 31 No. 1, p. 33.

Krause, D.R. and Scannell, T. V. (2002b), "Supplier Development Practices : Product- and Service-Based Industry Comparisons", *The Journal of Supply Chain Management*, Vol. 38 No. 1, pp. 13–21.

Kumar Pradhan, S., Routroy, S. and Pradhan, S.K. (2014), "Analyzing the performance of supplier development : a case study", *International Journal of Productivity and Performance Management*, Emerald Group Publishing Limited, Vol. 63 No. 2, pp. 209–233.

Kumar, C.V.S. and Routroy, S. (2014), "Addressing the Root Cause Impediments for Supplier Development in Manufacturing Environment", *Procedia Engineering*, Elsevier, Vol. 97, pp. 2136–2146.

Kumar, C.V.S. and Routroy, S. (2015), "Demystifying Manufacturer Satisfaction through Kano Model", *Materials Today: Proceedings*, Elsevier, Vol. 2 No. 4, pp. 1585–1594.

Kumar, C.V.S. and Routroy, S. (2016), "Case Application of a Methodology for Determining a Manufacturer's Preferred Customer Status with Suppliers", *Engineering Management Journal*, Taylor & Francis, Vol. 28 No. 1, pp. 25–38.

Kumar, N., Andersson, D., Isaksson, A. and Olofsson, M. (2011), "Supplier risk management in direct sourcing from China", *International Journal of Procurement Management*, Vol. 4 No. 4, p. 363.

Kumar, P., Shankar, R. and Yadav, S.S. (2012), "An analysis of supplier development issues in global context: an approach of fuzzy based modelling", *International Journal of Logistics*

Systems and Management, Vol. 11 No. 3, p. 407.

Kwong, C.K. and Bai, H. (2003), “Determining the importance weights for the customer requirements in QFD using a fuzzy AHP with an extent analysis approach”, *Iie Transactions*, Taylor & Francis, Vol. 35 No. 7, pp. 619–626.

Lacoste, S. (2012), “‘Vertical coopetition’: The key account perspective”, *Industrial Marketing Management*, Elsevier Inc., Vol. 41 No. 4, pp. 649–658.

Lager, T. and Storm, P. (2012), “Application development in supplier-customer collaborations: success factors for firms in the process industries”, *International Journal of Technology Marketing*, Inderscience, Vol. 7 No. 2, pp. 151–176.

Lai, K., Yeung, A.C.L. and Cheng, T.C.E. (2012), “Configuring quality management and marketing implementation and the performance implications for industrial marketers”, *Industrial Marketing Management*, Elsevier, Vol. 41 No. 8, pp. 1284–1297.

Lam, P.-K. and Chin, K.-S. (2005), “Identifying and prioritizing critical success factors for conflict management in collaborative new product development”, *Industrial Marketing Management*, Elsevier, Vol. 34 No. 8, pp. 761–772.

Lam, P.-K., Chin, K.-S., Yang, J.-B. and Liang, W. (2007), “Self-assessment of conflict management in client-supplier collaborative new product development”, *Industrial Management & Data Systems*, Emerald Group Publishing Limited, Vol. 107 No. 5, pp. 688–714.

Lambert, D.M. and Cooper, M.C. (2000), “Issues in supply chain management”, *Industrial marketing management*, Elsevier, Vol. 29 No. 1, pp. 65–83.

Large, R.O., Gimenez, C. and Thomsen, C.G. (2011), “Drivers of green supply management performance: Evidence from Germany”, *Journal of Purchasing and Supply Management*, Elsevier, Vol. 17 No. 3, pp. 176–184.

Larson, P.D. and Kulchitsky, J.D. (2000), “The use and impact of communication media in purchasing and supply management”, *The Journal of Supply Chain Management*, No. August, pp. 29–39.

Lascelles, D.M. and Dale, B.G. (1989a), “The buyer-supplier relationship in total quality management”, *Journal of Supply Chain Management*, Blackwell Publishing Ltd., Vol. 25 No. 2, p. 10.

Lascelles, D.M. and Dale, B.G. (1989b), “The Buyer-Supplier Relationship in Total Quality Management”, *Journal of Purchasing & Materials Management*, Vol. 25 No. 2, pp. 10–19.

Lascelles, D.M. and Dale, B.G. (1990a), “Examining the Barriers to Supplier Development”, *International Journal of Quality & Reliability Management*, Vol. 7 No. 2, doi:10.1108/EUM0000000001631.

Lascelles, D.M.D.M. and Dale, B.G.B.G. (1990b), “Examining the Barriers to Supplier Development”, *International Journal of Quality & Reliability Management*, MCB UP Ltd, Vol. 7 No. 2, doi:10.1108/EUM0000000001631.

Lavastre, O., Gunasekaran, A. and Spalanzani, A. (2012), “Supply chain risk management in French companies”, *Decision Support Systems*, Elsevier, Vol. 52 No. 4, pp. 828–838.

Lawson, B., Krause, D. and Potter, A. (2014), “Improving Supplier New Product Development Performance: The Role of Supplier Development”, *Journal of Product Innovation Management*, Wiley Online Library, Vol. 32 No. 5, pp. 777–792.

Lawson, B. and Potter, A. (2012), “Determinants of knowledge transfer in inter-firm new product development projects”, *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 32 No. 10, pp. 1228–1247.

Lee, A.H.I. (2009), “A fuzzy supplier selection model with the consideration of benefits, opportunities, costs and risks”, *Expert systems with applications*, Elsevier, Vol. 36 No. 2, pp. 2879–2893.

Lee, A.H.I., Kang, H.-Y. and Chang, C.-T. (2009), “Fuzzy multiple goal programming applied to TFT-LCD supplier selection by downstream manufacturers”, *Expert Systems with Applications*, Elsevier, Vol. 36 No. 3, pp. 6318–6325.

Lee, A.H.I., Kang, H.-Y., Hsu, C.-F. and Hung, H.-C. (2009), “A green supplier selection model for high-tech industry”, *Expert systems with applications*, Elsevier, Vol. 36 No. 4, pp. 7917–7927.

Lee, G.L. (1995), “The ‘pros’ and ‘cons’ of total quality management for smaller firms in manufacturing: Some experiences down the supply chain”, *Total Quality Management*, Vol. 6 No. 4, pp. 413–426.

Lee, H.L. (2008), “Embedding sustainability: lessons from the front line”, *International Commerce Review*, Springer, Vol. 8 No. 1, pp. 10–20.

Lee, K. and Kim, J. (2011), “Integrating suppliers into green product innovation development: an empirical case study in the semiconductor industry”, *Business Strategy and the Environment*, Wiley Online Library, Vol. 20 No. 8, pp. 527–538.

Leenders, M.R. (1965), *Improving purchasing effectiveness through supplier development*, Division of Research, Graduate School of Business Administration, Harvard University.

Leenders, M.R. (1989), “Supplier development”, *Journal of Purchasing & Materials Management*, National Association of Purchasing Management, Inc., Vol. 25 No. 1, pp. 47–62.

Leenders, M.R. and Blenkhorn, D.L. (1988), *Reverse marketing: The new buyer-supplier relationship*, New York: Free Press; London: Collier Macmillan.

Leuschner, R., Rogers, D.S. and Charvet, F.F. (2013), “A Meta-Analysis of Supply Chain Integration and Firm Performance”, *Journal of Supply Chain Management*, Wiley Online Library, Vol. 49 No. 2, pp. 34–57.

Levina, N. and Su, N. (2008), “Global multisourcing strategy: The emergence of a supplier portfolio in services offshoring”, *Decision Sciences*, Wiley Online Library, Vol. 39 No. 3, pp. 541–570.

Li, W., Humphreys, P.K., Yeung, A.C.L. and Cheng, T.C.E. (2012), “The impact of supplier development on buyer competitive advantage: A path analytic model”, *International Journal of Production Economics*, Elsevier, Vol. 135 No. 1, pp. 353–366.

Li, Y., Xie, E., Teo, H.-H. and Peng, M.W. (2010), “Formal control and social control in domestic and international buyer–supplier relationships”, *Journal of Operations Management*, Elsevier, Vol. 28 No. 4, pp. 333–344.

Liao, K., Deng, X. and Marsillac, E. (2013), “Factors that influence Chinese automotive suppliers’ mass customization capabilities”, *International Journal of Production Economics*, Elsevier, Vol. 146 No. 1, pp. 25–36.

Lindwall, C., Ellmo, A., Rehme, J. and Kowalkowski, C. (2010), “Increasing customer attractiveness through upstream brand equity”, *The International IPSERA workshop on Customer attractiveness, supplier satisfaction and customer value*, IPSERA.

Lloyd, C. and James, S. (2008), “Too much pressure? Retailer power and occupational health and safety in the food processing industry”, *Work, employment & society*, SAGE Publications, Vol. 22 No. 4, pp. 713–730.

Lockstroem, M., Schadel, J., Harrison, N., Moser, R. and Malhotra, M.K. (2010), “Antecedents to supplier integration in the automotive industry: a multiple-case study of foreign subsidiaries in China”, *Journal of Operations Management*, Elsevier, Vol. 28 No. 3, pp. 240–256.

Lockström, M. and Lei, L. (2012), “The role of resources in global sourcing: development of a theoretical framework”, *International Journal of Integrated Supply Management*, Inderscience, Vol. 7 No. 1, pp. 38–60.

Lockström, M. and Lei, L. (2013), “Antecedents to supplier integration in China: A partial least squares analysis”, *International Journal of Production Economics*, Vol. 141 No. 1, pp. 295–306.

Loppacher, J.S., Cagliano, R. and Spina, G. (2011), “Key drivers of buyer-supplier relationships in global sourcing strategies”, *International Journal of Procurement Management*, Inderscience Publishers, Vol. 4 No. 2, pp. 156–180.

Lorentz, H., Kittipanya-ngam, P. and Srai, J.S. (2013), “Emerging market characteristics and supply network adjustments in internationalising food supply chains”, *International Journal of Production Economics*, Elsevier, Vol. 145 No. 1, pp. 220–232.

Lu, R.X.A.A., Lee, P.K.C.C. and Cheng, T.C.E.C.E. (2012), “Socially responsible supplier development: Construct development and measurement validation”, *International Journal of Production Economics*, Elsevier, Vol. 140 No. 1, pp. 160–167.

Luzzini, D., Amann, M., Caniato, F., Essig, M. and Ronchi, S. (2015), “The path of innovation: purchasing and supplier involvement into new product development”, *Industrial Marketing*

Management, Elsevier, Vol. 47, pp. 109–120.

Mahapatra, S.K., Das, A. and Narasimhan, R. (2012), "A contingent theory of supplier management initiatives: Effects of competitive intensity and product life cycle", *Journal of Operations Management*, Elsevier B.V., Vol. 30 No. 5, pp. 406–422.

Mahapatra, S.K., Narasimhan, R. and Barbieri, P. (2010), "Strategic interdependence, governance effectiveness and supplier performance: A dyadic case study investigation and theory development", *Journal of Operations Management*, Elsevier, Vol. 28 No. 6, pp. 537–552.

Mahmood, M. and Humphrey, J. (2013), "Stakeholder expectation of corporate social responsibility practices: a study on local and multinational corporations in Kazakhstan", *Corporate Social Responsibility and Environmental Management*, Wiley Online Library, Vol. 20 No. 3, pp. 168–181.

Makkonen, H., Vuori, M. and Puranen, M. (2015), "Buyer attractiveness as a catalyst for buyer–supplier relationship development", *Industrial Marketing Management*, Elsevier.

Manuj, I., Omar, A. and Yazdanparast, A. (2013), "The quest for competitive advantage in global supply chains", *Transportation Journal*, JSTOR, Vol. 52 No. 4, pp. 463–492.

Martínez-de-Albéniz, V. and Simchi-Levi, D. (2013), "Supplier–Buyer negotiation games: Equilibrium conditions and supply chain efficiency", *Production and Operations Management*, Wiley Online Library, Vol. 22 No. 2, pp. 397–409.

Masi, D., Micheli, G.J.L. and Cagno, E. (2013), "A meta-model for choosing a supplier selection technique within an EPC company", *Journal of Purchasing and Supply Management*, Elsevier, Vol. 19 No. 1, pp. 5–15.

Matook, S., Lasch, R. and Tamaschke, R. (2009), "Supplier development with benchmarking as part of a comprehensive supplier risk management framework", *International Journal of Operations & Production Management*, Vol. 29 No. 3, pp. 241–267.

McCarthy, T.M. and Golicic, S.L. (2002), "Implementing collaborative forecasting to improve supply chain performance", *International Journal of Physical Distribution & Logistics Management*, MCB UP Ltd, Vol. 32 No. 6, pp. 431–454.

McDonald, R.P. and Marsh, H.W. (1990), "Choosing a multivariate model: Noncentrality and goodness of fit.", *Psychological bulletin*, American Psychological Association, Vol. 107 No. 2, p. 247.

McIvor, R. (2011), "Outsourcing done right", *Industrial Engineer*, Vol. 43 No. 1, pp. 30–35.

Meehan, J. and Wright, G.H. (2011), "Power priorities: A buyer–seller comparison of areas of influence", *Journal of Purchasing and Supply Management*, Elsevier, Vol. 17 No. 1, pp. 32–41.

Mehta, V. (2014), "Auto component sector in India , the pride of manufacturing industry", *IBEF BLOGS*.

Melewar, T.C., Alwi, S., Gorane, S.J. and Kant, R. (2013), "Modelling the SCM enablers: an integrated ISM-fuzzy MICMAC approach", *Asia Pacific Journal of Marketing and Logistics*, Emerald Group Publishing Limited, Vol. 25 No. 2, pp. 263–286.

Millet, I. and Wedley, W.C. (2002), "Modelling risk and uncertainty with the analytic hierarchy process", *Journal of Multi‐Criteria Decision Analysis*, Wiley Online Library, Vol. 11 No. 2, pp. 97–107.

Mishra, S., Samantra, C., Datta, S. and Mahapatra, S.S. (2013), "Supplier evaluation in agile supply chain in fuzzy paradigm", *International Journal of Services and Operations Management*, Inderscience Publishers Ltd, Vol. 16 No. 1, pp. 1–41.

Mitra, S. and Datta, P.P. (2013), "A survey of sustainable supply chain management practices in Indian manufacturing firms", *Indian Institute of Management Calcutta, Working Paper Series, WPS No*, Vol. 723.

Miyamoto, T. and Rexha, N. (2004), "Determinants of three facets of customer trust. A marketing model of Japanese buyer-supplier relationship", *Journal of Business Research*, Vol. 57 No. 3, pp. 312–319.

Modi, S.B. and Mabert, V.A. (2007), "Supplier development: Improving supplier performance through knowledge transfer", *Journal of Operations Management*, Vol. 25 No. 1, pp. 42–64.

Mohanty, M.K., Gahan, P. and Choudhury, S. (2014), "Why most of the supplier development programs fail in discrete manufacturing–findings from selected Indian discrete manufacturing industries", *International Journal of Management Science and Engineering Management*, Taylor & Francis, Vol. 9 No. 3, pp. 201–211.

Monczka, R., Handfield, R., Giunipero, L. and Patterson, J. (2015), *Purchasing and supply chain management*, Cengage Learning.

Monczka, R.M. and Petersen, K.J. (2012), "The competitive potential of supply management", *Supply Chain Management Review*, Vol. 16 No. 5.

Monczka, R.M. and Trent, R.J. (1991), "Evolving sourcing strategies for the 1990s", *International Journal of Physical Distribution & Logistics Management*, MCB UP Ltd, Vol. 21 No. 5, pp. 4–12.

Monczka, R.M., Trent, R.J. and Callahan, T.J. (1993), "Supply base strategies to maximize supplier performance", *International Journal of Physical Distribution & Logistics Management*, MCB UP Ltd, Vol. 23 No. 4, pp. 42–54.

Moody, P.E. (1992), "Customer supplier integration: Why being an excellent customer counts", *Business horizons*, Elsevier, Vol. 35 No. 4, pp. 52–57.

Moore, S.B. and Manring, S.L. (2009), "Strategy development in small and medium sized enterprises for sustainability and increased value creation", *Journal of cleaner production*, Elsevier, Vol. 17 No. 2, pp. 276–282.

Morgan, J. (1993), "Supplier programs take time to become world class", *Purchasing*, Vol. 19 No.

August, pp. 61–63.

Morris, M., Kaplinsky, R. and Kaplan, D. (2012), "'One thing leads to another'—Commodities, linkages and industrial development", *Resources Policy*, Elsevier, Vol. 37 No. 4, pp. 408–416.

Mortensen, M. and Arlbjørn, J. (2012), "Inter-organisational supplier development: the case of customer attractiveness and strategic fit", *Supply Chain Management: An International Journal*, Vol. 17 No. 2, pp. 152–171.

Mortensen, M.H. (2012), "Understanding attractiveness in business relationships—A complete literature review", *Industrial Marketing Management*, Elsevier, Vol. 41 No. 8, pp. 1206–1218.

Moser, R. (2007), *Strategic purchasing and supply management: A strategy-based selection of suppliers*, Springer Science & Business Media.

Motwani, J., Youssef, M., Kathawala, Y. and Futch, E. (1999), "Supplier selection in developing countries: a model development", *Integrated Manufacturing Systems*, MCB UP Ltd, Vol. 10 No. 3, pp. 154–162.

Mulaik, S.A., James, L.R., Van Alstine, J., Bennett, N., Lind, S. and Stilwell, C.D. (1989), "Evaluation of goodness-of-fit indices for structural equation models.", *Psychological bulletin*, American Psychological Association, Vol. 105 No. 3, p. 430.

Mwikali, R. and Kavale, S. (2012), "Factors affecting the selection of optimal suppliers in procurement management", *International Journal of Humanities and Social Science*, Vol. 2 No. 14, pp. 189–193.

Myers, M.B. and Cheung, M. (2008), "Sharing global supply chain knowledge", *MIT Sloan Management Review*, Vol. 49 No. 4, pp. 65–74.

Nagati, H. and Rebolledo, C. (2013), "Supplier development efforts: The suppliers' point of view", *Industrial Marketing Management*, Elsevier Inc., Vol. 42 No. 2, pp. 180–188.

Nagle, T.T. and Cressman Jr, G.E. (2002), "Don't just set prices, manage them", *Marketing Management*, American Marketing Association, Vol. 11 No. 6, p. 29.

Najafi Tavani, S., Sharifi, H. and S. Ismail, H. (2013), "A study of contingency relationships between supplier involvement, absorptive capacity and agile product innovation", *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 34 No. 1, pp. 65–92.

Narasimhan, R., Mahapatra, S. and Arlbjørn, J.S. (2008), "Impact of relational norms, supplier development and trust on supplier performance", *Operations Management Research*, Springer, Vol. 1 No. 1, pp. 24–30.

Narasimhan, R. and Narayanan, S. (2013), "Perspectives on Supply Network–Enabled Innovations", *Journal of Supply Chain Management*, Wiley Online Library, Vol. 49 No. 4, pp. 27–42.

Narayanan, S., Narasimhan, R. and Schoenherr, T. (2014), "Assessing the contingent effects of collaboration on agility performance in buyer-supplier relationships", *Journal of Operations Management*, Elsevier.

Narayanan, S., Narasimhan, R. and Schoenherr, T. (2015), "Assessing the contingent effects of collaboration on agility performance in buyer–supplier relationships", *Journal of Operations Management*, Elsevier, Vol. 33, pp. 140–154.

Nasim, S. (2011), "Total interpretive structural modeling of continuity and change forces in e-government", *Journal of Enterprise Transformation*, Taylor & Francis, Vol. 1 No. 2, pp. 147–168.

Neilson, J. and Pritchard, B. (2007), "Green coffee? The contradictions of global sustainability initiatives from an Indian perspective", *Development Policy Review*, Vol. 25 No. 3, pp. 311–331.

Neven, D., Odera, M.M., Reardon, T. and Wang, H. (2009), "Kenyan supermarkets, emerging middle-class horticultural farmers, and employment impacts on the rural poor", *World Development*, Elsevier, Vol. 37 No. 11, pp. 1802–1811.

New, S. (2013), "Understanding Supplier Resistance - Overcoming Obstacles to Supply Innovation", *Nang Yan Business Journal*, Vol. 2 No. 1, pp. 168–173.

Nollet, J., Rebolledo, C. and Popel, V. (2012), "Becoming a preferred customer one step at a time", *Industrial Marketing Management*, Elsevier Inc., Vol. 41 No. 8, pp. 1186–1193.

Nord, W. (1997), "Managing with power", *The Leadership Quarterly*, Vol. 8 No. 1, pp. 89–91.

Olsen, R.F. and Ellram, L.M. (1997), "A portfolio approach to supplier relationships", *Industrial marketing management*, Elsevier, Vol. 26 No. 2, pp. 101–113.

Opricovic, S. and Tzeng, G.-H. (2003), "Defuzzification within a multicriteria decision model", *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems*, World Scientific, Vol. 11 No. 05, pp. 635–652.

Paik, S.-K. (2014), "A Portfolio Approach to Purchasing Development in Small and Medium Sized Enterprises (SMEs)", *Journal of Supply Chain and Operations Management*, Vol. 12 No. 1, p. 1.

Pal, R., Torstensson, H. and Mattila, H. (2014), "Antecedents of organizational resilience in economic crises—an empirical study of Swedish textile and clothing SMEs", *International Journal of Production Economics*, Elsevier, Vol. 147, pp. 410–428.

Panayides, P.M. and Venus Lun, Y.H. (2009), "The impact of trust on innovativeness and supply chain performance", *International Journal of Production Economics*, Elsevier, Vol. 122 No. 1, pp. 35–46.

Panizzolo, R., Garengo, P., Sharma, M.K. and Gore, A. (2012), "Lean manufacturing in developing countries: evidence from Indian SMEs", *Production Planning & Control*, Taylor & Francis, Vol. 23 No. 10-11, pp. 769–788.

Park, J., Shin, K., Chang, T.-W. and Park, J. (2010), "An integrative framework for supplier relationship management", *Industrial Management & Data Systems*, Emerald Group Publishing Limited, Vol. 110 No. 4, pp. 495–515.

Parker, D.B., Zsidisin, G.A. and Ragatz, G.L. (2008), "Timing and extent of supplier integration in new product development: a contingency approach", *Journal of Supply Chain Management*, Wiley Online Library, Vol. 44 No. 1, pp. 71–83.

Patil, S.K. and Kant, R. (2014), "A fuzzy AHP-TOPSIS framework for ranking the solutions of Knowledge Management adoption in Supply Chain to overcome its barriers", *Expert Systems with Applications*, Elsevier, Vol. 41 No. 2, pp. 679–693.

Payan, J.M. and McFarland, R.G. (2005), "Decomposing influence strategies: argument structure and dependence as determinants of the effectiveness of influence strategies in gaining channel member compliance", *Journal of Marketing*, American Marketing Association, Vol. 69 No. 3, pp. 66–79.

Petison, P. and Johri, L.M. (2008), "Dynamics of the manufacturer-supplier relationships in emerging markets: A case of Thailand", *Asia Pacific Journal of Marketing and Logistics*, Vol. 20 No. 1, pp. 76–96.

Phillips, W., Lamming, R. and Caldwell, N. (2012), "Customer-supplier relationships during the process of innovation: An innovation systems approach", *Strategic Change*, Wiley Online Library, Vol. 21 No. 5-6, pp. 263–274.

Pieter van Donk, D., van der Vaart, T., Awaysheh, A. and Klassen, R.D. (2010), "The impact of supply chain structure on the use of supplier socially responsible practices", *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 30 No. 12, pp. 1246–1268.

Ponomarov, S.Y. and Holcomb, M.C. (2009), "Understanding the concept of supply chain resilience", *The International Journal of Logistics Management*, Emerald Group Publishing Limited, Vol. 20 No. 1, pp. 124–143.

Porteous, A.H., Rammohan, S. V, Cohen, S. and Lee, H.L. (2012), "Maturity in Responsible Supply Chain Management", pp. 1–14.

Potter, A. and Lawson, B. (2013), "Help or hindrance? Causal ambiguity and supplier involvement in new product development teams", *Journal of Product Innovation Management*, Wiley Online Library, Vol. 30 No. 4, pp. 794–808.

Praharsi, Y., Dioquino, M.L.A. and Wee, H.-M. (2013), "Supply Risk Management via Social Capital Theory and Its Impact on Buyer's Performance Improvement and Innovation", *Proceedings of the Institute of Industrial Engineers Asian Conference 2013*, Springer, pp. 549–557.

Prahinski, C. and Benton, W.. (2004), "Supplier evaluations: communication strategies to improve supplier performance", *Journal of Operations Management*, Vol. 22 No. 1, pp. 39–62.

Prahinski, C. and Fan, Y. (2007), "Supplier evaluations: the role of communication quality", *Journal of Supply Chain Management*, Wiley Online Library, Vol. 43 No. 3, pp. 16–28.

Prajogo, D., Chowdhury, M., Yeung, A.C.L. and Cheng, T.C.E. (2012), “The relationship between supplier management and firm’s operational performance: A multi-dimensional perspective”, *International Journal of Production Economics*, Elsevier, Vol. 136 No. 1, pp. 123–130.

Praxmarer-Carus, S., Sucky, E. and Durst, S.M. (2013), “The relationship between the perceived shares of costs and earnings in supplier development programs and supplier satisfaction”, *Industrial Marketing Management*, Elsevier Inc., Vol. 42 No. 2, pp. 202–210.

Pulles, N.J., Schiele, H., Veldman, J. and Hüttinger, L. (2015), “The impact of customer attractiveness and supplier satisfaction on becoming a preferred customer”, *Industrial marketing management*, Elsevier.

Pulles, N.J., Veldman, J. and Schiele, H. (2014), “Identifying innovative suppliers in business networks: An empirical study”, *Industrial marketing management*, Elsevier, Vol. 43 No. 3, pp. 409–418.

Punniyamoorthy, M., Mathiyalagan, P. and Parthiban, P. (2011), “A strategic model using structural equation modeling and fuzzy logic in supplier selection”, *Expert Systems with Applications*, Elsevier, Vol. 38 No. 1, pp. 458–474.

Quayle, M. (2000), “Supplier Development for UK Small and Medium-sized Enterprises”, *Journal of Applied Management Studies*, Vol. 9 No. 1, pp. 37–41.

Raafat, F., Judge, R. and Shrimali, L. (2012), “Analysis of success factors in supplier development”, *International Journal of Logistics Economics and Globalisation*, Inderscience, Vol. 4 No. 4, pp. 289–308.

Rădulescu, I.G., Popescu, C. and Matei, M. (2010), “Conceptual Aspects of Shadow Economy”, *Transactions on Business and Economics–WSEAS*, Vol. 7, pp. 160–169.

Raizada, S. (2011), “7 ‘S’Model of Business Branding”, *International Journal of Industrial Marketing*, Vol. 1 No. 1, p. Pages–119.

Raj Sinha, P., Whitman, L.E. and Malzahn, D. (2004), “Methodology to mitigate supplier risk in an aerospace supply chain”, *Supply Chain Management: an international journal*, Emerald Group Publishing Limited, Vol. 9 No. 2, pp. 154–168.

Rajesh, R. and Ravi, V. (2015), “Supplier selection in resilient supply chains: a grey relational analysis approach”, *Journal of Cleaner Production*, Elsevier, Vol. 86, pp. 343–359.

Ralston, P.M., Blackhurst, J., Cantor, D.E. and Crum, M.R. (2015), “A Structure–Conduct–Performance Perspective of How Strategic Supply Chain Integration Affects Firm Performance”, *Journal of Supply Chain Management*, Wiley Online Library, Vol. 51 No. 2, pp. 47–64.

Ramsay, J. and Wagner, B.A. (2009), “Organisational Supplying Behaviour: Understanding supplier needs, wants and preferences”, *Journal of Purchasing and Supply Management*, Elsevier, Vol. 15 No. 2, pp. 127–138.

Reed, F.M. and Walsh, K. (2002), “Enhancing technological capability through supplier development: A study of the U.K. aerospace industry”, *IEEE Transactions on Engineering Management*, Vol. 49 No. 3, pp. 231–242.

Rees, H. (2011), “Supply Chain Management as a Competitive Weapon”, *Supply Chain Management in the Drug Industry*, Vol. 54 No. 1, pp. 125–153.

Ritchie, B. and Brindley, C. (2007), “Supply chain risk management and performance: A guiding framework for future development”, *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 27 No. 3, pp. 303–322.

Robert, M & Monczka, R. (1989), “Cooperative Buyer / Seller Relationships And A Firm ’ s Competitive Posture”, *Journal of Purchasing and Materials Management*, Vol. 25 No. 4, pp. 9–17.

La Rocca, A., Caruana, A. and Snehota, I. (2012), “Measuring customer attractiveness”, *Industrial Marketing Management*, Elsevier, Vol. 41 No. 8, pp. 1241–1248.

Rogerson, C.M. (2012), “Supplier diversity: A new phenomenon in private sector procurement in South Africa”, *Urban forum*, Springer, Vol. 23, pp. 279–297.

Roloff, J. and Aßländer, M.S. (2010), “Corporate autonomy and buyer–supplier relationships: The case of unsafe Mattel toys”, *Journal of business ethics*, Springer, Vol. 97 No. 4, pp. 517–534.

Roloff, J., Aßländer, M.S. and Zamantili Nayir, D. (2015), “The supplier perspective: forging strong partnerships with buyers”, *Journal of Business Strategy*, Emerald Group Publishing Limited, Vol. 36 No. 1, pp. 25–32.

Rosell, D.T. (2013), *Knowledge integration and innovation in buyer-supplier collaborations*, Linköping University Electronic Press, available at: urn:nbn:se:liu:diva-88028.

Rotich, G.C., Aburi, E.O. and Kihara, A.S.N. (2014), “The influence of specific supplier development practices on a firm’s competitive advantage: A case study of Safaricom Limited”, *International Journal of Social Sciences and Entrepreneurship*, Vol. 1 No. 11, pp. 70–75.

Routroy, S. and Kumar Pradhan, S. (2014), “Benchmarking model of supplier development for an Indian gear manufacturing company”, *Benchmarking: An International Journal*, Emerald Group Publishing Limited, Vol. 21 No. 2, pp. 253–275.

Routroy, S. and Kumar, C.V.S. (2015), “Strategy for supplier development program implementation: a case study”, *International Journal of Services and Operations Management*, Inderscience Publishers (IEL), Vol. 21 No. 2, pp. 238–264.

Routroy, S. and Pradhan, S.K. (2013a), “Evaluating the critical success factors of supplier development: a case study”, *Benchmarking: An International Journal*, Emerald Group Publishing Limited, Vol. 20 No. 3, pp. 322–341.

Routroy, S. and Pradhan, S.K. (2013b), “Analyzing the sourcing alternatives in an Indian manufacturing company”, *Journal of Advances in Management Research*, Emerald Group

Publishing Limited, Vol. 10 No. 1, pp. 22–44.

Routroy, S. and Sunil Kumar, C. V. (2014), "Analyzing supplier development program enablers using fuzzy DEMATEL", *Measuring Business Excellence*, Emerald Group Publishing Limited, Vol. 18 No. 4, pp. 1–26.

Ruben, R., Boselie, D. and Lu, H. (2007), "Vegetables procurement by Asian supermarkets: a transaction cost approach", *Supply Chain Management: An International Journal*, Emerald Group Publishing Limited, Vol. 12 No. 1, pp. 60–68.

Ruhrmann, S., Hochdörffer, J. and Lanza, G. (2014), "A methodological approach to evaluate supplier development based on real options", *Production Engineering*, Springer, Vol. 8 No. 3, pp. 373–382.

Rutherford, T. and Holmes, J. (2008), "'The flea on the tail of the dog': power in global production networks and the restructuring of Canadian automotive clusters", *Journal of Economic Geography*, Oxford Univ Press, Vol. 8 No. 4, pp. 519–544.

Rutherford, T.D. and Holmes, J. (2007), "'We Simply Have to Do that Stuff for our Survival': Labour, Firm Innovation and Cluster Governance in the Canadian Automotive Parts Industry", *Antipode*, Vol. 39 No. 1, pp. 194–221.

Saaty, T.L. (1980), "The analytic hierarchy process: planning, priority setting, resources allocation", *New York: McGraw*.

Saaty, T.L. (1990), "How to make a decision: the analytic hierarchy process", *European journal of operational research*, Elsevier, Vol. 48 No. 1, pp. 9–26.

Saaty, T.L. (2000), *Fundamentals of decision making and priority theory with the analytic hierarchy process*, Rws Publications, Vol. 6.

Saenz, M.J., Revilla, E. and Knoppen, D. (2014), "Absorptive capacity in buyer–supplier relationships: empirical evidence of its mediating role", *Journal of Supply Chain Management*, Wiley Online Library, Vol. 50 No. 2, pp. 18–40.

Safa, M., Shahi, A., Haas, C.T. and Hipel, K.W. (2014), "Supplier selection process in an integrated construction materials management model", *Automation in Construction*, Elsevier, Vol. 48, pp. 64–73.

Sage, A.P. (1977), *Interpretive structural modeling: methodology for large-scale systems*, McGraw-Hill, New York.

Sako, M. (2004), "Supplier development at Honda, Nissan and Toyota: comparative case studies of organizational capability enhancement", *Industrial and Corporate Change*, Vol. 13 No. 2, pp. 281–308.

Salam, M.A. (2011), "Innovative Methods for Supplier Evaluation and Selection", *GSTF Business Review (GBR)*, pp. 1–9.

Sánchez-Rodríguez, C., Hemsworth, D. and Martínez-Lorente, Á.R. (2005), "The effect of supplier development initiatives on purchasing performance: a structural model", *Supply Chain Management: An International Journal*, Vol. 10 No. 4, pp. 289–301.

Sarkar, A. and Mohapatra, P.K.J. (2006), "Evaluation of supplier capability and performance: A method for supply base reduction", *Journal of Purchasing and Supply Management*, Elsevier, Vol. 12 No. 3, pp. 148–163.

Sarkis, J. (2012), "Benchmarking and process change for green supply chain management", *Handbook of sustainability management*, World Scientific, pp. 87–108.

Schiele, H. (2010), "Early supplier integration: the dual role of purchasing in new product development", *R&D Management*, Wiley Online Library, Vol. 40 No. 2, pp. 138–153.

Schiele, H. (2012), "Accessing Supplier Innovation By Being Their Preferred Customer", *Research-Technology Management*.

Schiele, H., Calvi, R. and Gibbert, M. (2012), "Customer attractiveness, supplier satisfaction and preferred customer status: Introduction, definitions and an overarching framework", *Industrial Marketing Management*, Elsevier B.V., Vol. 41 No. 8, pp. 1178–1185.

Schiele, H., Ellis, S.C., Eßig, M., Henke, J.W. and Kull, T.J. (2015), "Managing supplier satisfaction: Social capital and resource dependence frameworks", *Australasian Marketing Journal (AMJ)*, Elsevier, Vol. 23 No. 2, pp. 132–138.

Schiele, H., Veldman, J. and Hüttinger, L. (2011), "Supplier Innovativeness and Supplier Pricing: The Role of Preferred Customer Status", *International Journal of Innovation Management*, World Scientific, Vol. 15 No. 01, pp. 1–27.

Schiele, H., Veldman, J., Hüttinger, L. and Pulles, N. (2012), "Towards a social exchange theory perspective on preferred customership—concept and practice", *Supply management research*, Springer, pp. 133–151.

Schiele, H. and Vos, F.G.S. (2015), "Dependency on suppliers as a peril in the acquisition of innovations? The role of buyer attractiveness in mitigating potential negative dependency effects in buyer–supplier relations", *Australasian Marketing Journal (AMJ)*, Elsevier, Vol. 23 No. 2, pp. 139–147.

Schieritz, N. and GroBler, A. (2003), "Emergent structures in supply chains-a study integrating agent-based and system dynamics modeling", *System Sciences, 2003. Proceedings of the 36th Annual Hawaii International Conference on*, IEEE, p. 9–pp.

Şen, C.G., Şen, S. and Başlıgil, H. (2010), "Pre-selection of suppliers through an integrated fuzzy analytic hierarchy process and max-min methodology", *International Journal of Production Research*, Taylor & Francis, Vol. 48 No. 6, pp. 1603–1625.

Sevkli, M., Lenny Koh, S.C., Zaim, S., Demirbag, M. and Tatoglu, E. (2007), "An application of data envelopment analytic hierarchy process for supplier selection: a case study of BEKO in Turkey", *International Journal of Production Research*, Vol. 45 No. 9, pp. 1973–2003.

Sharma, M.J. and Yu, S.J. (2013), "Selecting critical suppliers for supplier development to improve supply management", *OPSEARCH*, Springer, Vol. 50 No. 1, pp. 42–59.

Sharma, M.K. and Bhagwat, R. (2006), "Practice of information systems: Evidence from select Indian SMEs", *Journal of manufacturing technology management*, Emerald Group Publishing Limited, Vol. 17 No. 2, pp. 199–223.

Sharma, S. (2013), "Development of supplier relationship including cost of defectives in the cyclic production", *Production Planning & Control*, Taylor & Francis, Vol. 24 No. 8-9, pp. 759–768.

Shaw, K., Shankar, R., Yadav, S.S. and Thakur, L.S. (2012), "Supplier selection using fuzzy AHP and fuzzy multi-objective linear programming for developing low carbon supply chain", *Expert systems with applications*, Elsevier, Vol. 39 No. 9, pp. 8182–8192.

Shokri, A., Nabhani, F. and Hodgson, S. (2010), "Supplier development practice: Arising the problems of upstream delivery for a food distribution SME in the UK", *Robotics and Computer-Integrated Manufacturing*, Elsevier, Vol. 26 No. 6, pp. 639–646.

Sieweke, J., Birkner, S. and Mohe, M. (2012), "Preferred supplier programs for consulting services: An exploratory study of German client companies", *Journal of Purchasing and Supply Management*, Elsevier, Vol. 18 No. 3, pp. 123–136.

Simpson, P.M., Siguaw, J.A. and White, S.C. (2002), "Measuring the performance of suppliers: an analysis of evaluation processes", *Journal of Supply Chain Management*, Wiley Online Library, Vol. 38 No. 4, pp. 29–41.

Singh, R., Seshadri, D.V.R., Kumra, R., Agndal, H. and Nilsson, U. (2012), "Open book practices in buyer-supplier relationships in India", *Journal of Business & Industrial Marketing*, Emerald Group Publishing Limited, Vol. 27 No. 3, pp. 196–210.

Singh, R.K., Garg, S.K. and Deshmukh, S.G. (2007), "Strategy development for competitiveness: a study on Indian auto component sector", *International Journal of Productivity and Performance Management*, Emerald Group Publishing Limited, Vol. 56 No. 4, pp. 285–304.

Smals, R.G.M. and Smits, A.A.J. (2012), "Value for value—The dynamics of supplier value in collaborative new product development", *Industrial Marketing Management*, Elsevier, Vol. 41 No. 1, pp. 156–165.

Smart, A.F. (2010), "E-procurement and its impact on supply management–evidence from industrial case studies", *International Journal of Logistics: Research and Applications*, Taylor & Francis, Vol. 13 No. 6, pp. 423–440.

Smets, L.P.M., van Oorschot, K.E., Langerak, F., Oorschot, K.E. and Langerak, F. (2013), "Don't Trust Trust: A Dynamic Approach to Controlling Supplier Involvement in New Product Development", *Journal of Product Innovation Management*, Wiley Online Library, Vol. 30 No. 6, pp. 1145–1158.

Smith, A.D. (2010), "Service quality programme developments and lean management aspects: a multi-case study", *International Journal of services and operations management*, Inderscience Publishers, Vol. 7 No. 1, pp. 1–23.

Sommer, R.A. (2004), “Architecting cross-functional business processes: new views on traditional business process reengineering”, *International Journal of Management and Enterprise Development*, Inderscience, Vol. 1 No. 4, pp. 345–358.

Song, Y., Su, Q., Liu, Q. and Wang, T. (2012), “Impact of business relationship functions on relationship quality and buyer’s performance”, *Journal of Business & Industrial Marketing*, Emerald Group Publishing Limited, Vol. 27 No. 4, pp. 286–298.

Srinivasan, M., Mukherjee, D. and Gaur, A.S. (2011), “Buyer–supplier partnership quality and supply chain performance: Moderating role of risks, and environmental uncertainty”, *European Management Journal*, Elsevier, Vol. 29 No. 4, pp. 260–271.

Srivastava, V. and Singh, T. (2013), “Exploring Determinants of Closeness in Manufacturer–Supplier Relationships: A Study of Select Indian Manufacturing Firms”, *Journal of Relationship Marketing*, Taylor & Francis, Vol. 12 No. 1, pp. 1–21.

Steiger, J.H. (1990), “Structural model evaluation and modification: An interval estimation approach”, *Multivariate behavioral research,* Taylor & Francis, Vol. 25 No. 2, pp. 173–180.

Steinle, C. and Schiele, H. (2008), “Limits to global sourcing?. Strategic consequences of dependency on international suppliers: Cluster theory, resource-based view and case studies”, *Journal of Purchasing and Supply Management*, Vol. 14 No. 1, pp. 3–14.

Steven, A.B., Dong, Y. and Corsi, T. (2014), “Global sourcing and quality recalls: An empirical study of outsourcing-supplier concentration-product recalls linkages”, *Journal of Operations Management*, Elsevier, Vol. 32 No. 5, pp. 241–253.

Stjernström, S., Bengtsson, L. and S. Stjernstro¨m, L.B. (2004), “Supplier perspective on business relationships: experiences from six small suppliers”, *Journal of Purchasing and Supply Management*, Elsevier, Vol. 10 No. 3, pp. 137–146.

Stuart, F.I. (1993), “Supplier partnerships: influencing factors and strategic benefits”, *International Journal of Purchasing and Materials Management*, Wiley Online Library, Vol. 29 No. 3, pp. 21–29.

Sucky, E. and Durst, S.M. (2013), “Supplier development : Current status of empirical research”, *International Journal of Procurement Management*, Inderscience, Vol. 6 No. 1, pp. 92–127.

Sullivan, U.Y., Peterson, R.M. and Krishnan, V. (2012), “Value creation and firm sales performance: The mediating roles of strategic account management and relationship perception”, *Industrial Marketing Management*, Elsevier, Vol. 41 No. 1, pp. 166–173.

Sushil, S. (2012), “Interpreting the interpretive structural model”, *Global Journal of Flexible Systems Management*, Vol. 13 No. 2, pp. 87–106.

Svensson, G., Mysen, T. and Payan, J. (2010), “Balancing the sequential logic of quality constructs in manufacturing-supplier relationships—Causes and outcomes”, *Journal of Business Research*, Elsevier, Vol. 63 No. 11, pp. 1209–1214.

Swinney, R. and Netessine, S. (2009), “Long-term contracts under the threat of supplier default”, *Manufacturing & Service Operations Management*, INFORMS, Vol. 11 No. 1, pp. 109–127.

Takeishi, A. (2001), “Bridging inter-and intra-firm boundaries: management of supplier involvement in automobile product development”, *Strategic management journal*, Wiley Online Library, Vol. 22 No. 5, pp. 403–433.

Talluri, S., DeCampos, H.A. and Hult, G.T.M. (2013), “Supplier rationalization: A sourcing decision model”, *Decision Sciences*, Wiley Online Library, Vol. 44 No. 1, pp. 57–86.

Talluri, S., Narasimhan, R. and Chung, W. (2010), “Manufacturer cooperation in supplier development under risk”, *European Journal of Operational Research*, Vol. 207 No. 1, pp. 165–173.

Tang, C.S. (2007), “Supplier Relationship Map ’”, *International Journal of Logistics Research and Applications*, No. February 2014, pp. 37–41.

Tang, S.Y., Gurnani, H. and Gupta, D. (2014), “Managing disruptions in decentralized supply chains with endogenous supply process reliability”, *Production and Operations Management*, Wiley Online Library, Vol. 23 No. 7, pp. 1198–1211.

Tavani, S.N., Sharifi, H., Soleimanof, S. and Najmi, M. (2013), “An empirical study of firm’s absorptive capacity dimensions, supplier involvement and new product development performance”, *International Journal of Production Research*, Taylor & Francis, Vol. 51 No. 11, pp. 3385–3403.

Thakkar, J., Kanda, A. and Deshmukh, S.G. (2013), “Supply chain issues in SMEs: select insights from cases of Indian origin”, *Production Planning & Control*, Taylor & Francis, Vol. 24 No. 1, pp. 47–71.

Thatte, A.A., Rao, S.S. and Ragu-Nathan, T.S. (2013), “Impact of SCM practices of a firm on supply chain responsiveness and competitive advantage of a firm”, *Journal of Applied Business Research (JABR)*, Vol. 29 No. 2, pp. 499–530.

Theng Lau, G. and Goh, M. (2005), “Buyer-seller relationships in the PCB industry”, *Supply Chain Management: An International Journal*, Emerald Group Publishing Limited, Vol. 10 No. 4, pp. 302–312.

Thomas, L. (2000), “Fundamentals of Decision Making and Priority Theory”, *Pittsburgh, PA: RWS Publications*, Vol. 21.

Thomas, R.W., Fugate, B.S. and Koukova, N.T. (2011), “Coping with time pressure and knowledge sharing in buyer–supplier relationships”, *Journal of Supply Chain Management*, Wiley Online Library, Vol. 47 No. 3, pp. 22–42.

Thun, J.-H., Drüke, M. and Hoenig, D. (2011), “Managing uncertainty – an empirical analysis of supply chain risk management in small and medium-sized enterprises”, *International Journal of Production Research*, Vol. 49 No. 18, pp. 5511–5525.

De Toni, A. and Nassimbeni, G. (2000), “Just-in-time purchasing: an empirical study of operational practices, supplier development and performance”, *Omega*, Vol. 28 No. 6, pp.

631–651.

Tóth, Z., Thiesbrummel, C., Henneberg, S.C. and Naudé, P. (2015), “Understanding configurations of relational attractiveness of the customer firm using fuzzy set QCA”, *Journal of Business Research*, Elsevier, Vol. 68 No. 3, pp. 723–734.

Trent, R.J. (2007), *Strategic supply management: creating the next source of competitive advantage*, J. Ross Publishing.

Trent, R.J. and Monczka, R.M. (1998), “Purchasing and supply management: trends and changes throughout the 1990s”, *International Journal of Purchasing and Materials Management*, Wiley Online Library, Vol. 34 No. 3, pp. 2–11.

Trent, R.J. and Monczka, R.M. (2003), “Understanding integrated global sourcing”, *International Journal of Physical Distribution & Logistics Management*, MCB UP Ltd, Vol. 33 No. 7, pp. 607–629.

Trkman, P. and McCormack, K. (2009), “Supply chain risk in turbulent environments—A conceptual model for managing supply chain network risk”, *International Journal of Production Economics*, Elsevier, Vol. 119 No. 2, pp. 247–258.

Ulaga, W. and Eggert, A. (2006), “Value-based differentiation in business relationships: Gaining and sustaining key supplier status”, *Journal of marketing*, American Marketing Association, Vol. 70 No. 1, pp. 119–136.

Vieira, L.M., Paiva, E.L., Finger, A.B. and Teixeira, R. (2013), “Trust and supplier-buyer relationships: an empirical analysis”, *BAR-Brazilian Administration Review*, SciELO Brasil, Vol. 10 No. 3, pp. 263–280.

Vinodh, S., Devadasan, S.R., Vimal, K.E.K. and Kumar, D. (2013), “Design of agile supply chain assessment model and its case study in an Indian automotive components manufacturing organization”, *Journal of Manufacturing Systems*, Elsevier, Vol. 32 No. 4, pp. 620–631.

Vrat, P. (2014), “Source Selection, Performance Rating, and Development”, *Materials Management*, Springer, pp. 317–337.

Wagner, B.A., Fillis, I. and Johansson, U. (2005), “An exploratory study of SME local sourcing and supplier development in the grocery retail sector”, *International Journal of Retail & Distribution Management*, Vol. 33 No. 10, pp. 716–733.

Wagner, S.M. (2006), “Supplier development practices: an exploratory study”, *European Journal of Marketing*, Vol. 40 No. 5/6, pp. 554–571.

Wagner, S.M. (2010), “Indirect and Direct Supplier Development: Performance Implications of Individual and Combined Effects”, *IEEE Transactions on Engineering Management*, IEEE, Vol. 57 No. 4, pp. 536–546.

Wagner, S.M. (2011), “Supplier development and the relationship life-cycle”, *International Journal of Production Economics*, Elsevier, Vol. 129 No. 2, pp. 277–283.

Wagner, S.M. and Bode, C. (2014), "Supplier relationship-specific investments and the role of safeguards for supplier innovation sharing", *Journal of Operations Management*, Elsevier, Vol. 32 No. 3, pp. 65–78.

Wagner, S.M. and Boutellier, R. (2002), "Capabilities for managing a portfolio of supplier relationships", *Business Horizons*, Elsevier, Vol. 45 No. 6, pp. 79–88.

Walter, A., Müller, T.A., Helfert, G. and Ritter, T. (2003), "Functions of industrial supplier relationships and their impact on relationship quality", *Industrial Marketing Management*, Elsevier, Vol. 32 No. 2, pp. 159–169.

Wang, C.L. and Ahmed, P.K. (2004), "The development and validation of the organisational innovativeness construct using confirmatory factor analysis", *European journal of innovation management*, Emerald Group Publishing Limited, Vol. 7 No. 4, pp. 303–313.

Wang, F.-K., Du, T. and Li, E. (2004), "Applying Six-Sigma to Supplier Development", *Total Quality Management & Business Excellence*, Vol. 15 No. 9-10, pp. 1217–1229.

Wang, W.-P. (2010), "A fuzzy linguistic computing approach to supplier evaluation", *Applied Mathematical Modelling*, Elsevier, Vol. 34 No. 10, pp. 3130–3141.

Warfield, J.W. (1974), "Developing interconnected matrices in structural modeling Institute of Electrical and Electronics Engineering Transactions on Systems", *Man and Cybernetics*, Vol. 4 No. 1, pp. 51–81.

Watts, Charles A.; Hahn, C.K. (1993), "Supplier Development Programs: An Empircial Analysis", *International Journal of Purchasing and Materials Management*, Vol. 29 No. 1, pp. 10–17.

Wee, H.M. and Widyadana, G.A. (2013), "Single-vendor single-buyer inventory model with discrete delivery order, random machine unavailability time and lost sales", *International Journal of Production Economics*, Elsevier, Vol. 143 No. 2, pp. 574–579.

Van Weele, A.J. (2009), *Purchasing and supply chain management: Analysis, strategy, planning and practice*, Cengage Learning EMEA.

Wen-li, L., Humphreys, P., Chan, L.. and Kumaraswamy, M. (2003), "Predicting purchasing performance: the role of supplier development programs", *Journal of Materials Processing Technology*, Vol. 138 No. 1-3, pp. 243–249.

Wilding, R., Wagner, B., Miemczyk, J., Johnsen, T.E. and Macquet, M. (2012), "Sustainable purchasing and supply management: a structured literature review of definitions and measures at the dyad, chain and network levels", *Supply Chain Management: An International Journal*, Emerald Group Publishing Limited, Vol. 17 No. 5, pp. 478–496.

Williamson, P.J. (1991), "Supplier strategy and customer responsiveness: Managing the links", *Business Strategy Review*, Wiley Online Library, Vol. 2 No. 2, pp. 75–90.

Wilson, N. (1996), "The supply chains of perishable products in northern Europe", *British Food Journal*, Vol. 98 No. 6, pp. 9–15.

Winter, C. (2003), "Working with Subcontractors", *Contractor-Led Procurement*, Springer, pp. 188–219.

Winter, S. and Lasch, R. (2011), "Management of Supplier Innovation: A Framework for Accessing and Realizing Innovation from Suppliers", *Sucky, E.; Asdecker, B.; Dobhan, A*, pp. 85–104.

Wu, H.-H. (2002), "A Comparative Study of Using Grey Relational Analysis in Multiple Attribute Decision Making Problems", *Quality Engineering*, Vol. 15 No. 2, pp. 209–217.

Wu, T., Daniel, E.M., Hinton, M. and Quintas, P. (2013), "Isomorphic mechanisms in manufacturing supply chains: a comparison of indigenous Chinese firms and foreign-owned MNCs", *Supply Chain Management: An International Journal*, Emerald Group Publishing Limited, Vol. 18 No. 2, pp. 161–177.

Wu, W.-W. (2008), "Choosing knowledge management strategies by using a combined ANP and DEMATEL approach", *Expert Systems with Applications*, Elsevier, Vol. 35 No. 3, pp. 828–835.

Wu, W.-W. and Lee, Y.-T. (2007), "Developing global managers' competencies using the fuzzy DEMATEL method", *Expert systems with applications*, Elsevier, Vol. 32 No. 2, pp. 499–507.

Wu, W.-Y., Lin, C., Chen, S. and Wang, H.-C. (2011), "The mediating effect of relationship learning on the relationship between supplier development strategy and raising competence", *African Journal of Business Research*, Vol. 5 No. 13, pp. 5136 – 5151.

Wu, Z., Choi, T.Y. and Rungtusanatham, M.J. (2010), "Supplier–supplier relationships in buyer–supplier–supplier triads: Implications for supplier performance", *Journal of Operations Management*, Elsevier, Vol. 28 No. 2, pp. 115–123.

Wynstra, F. and Ten Pierick, E. (2000), "Managing supplier involvement in new product development: a portfolio approach", *European Journal of Purchasing & Supply Management*, Elsevier, Vol. 6 No. 1, pp. 49–57.

Xia, Y., Chen, B. and Kouvelis, P. (2008), "Market-Based Supply Chain Coordination by Matching Suppliers' Cost Structures with Buyers' Order Profiles", *Management Science*, INFORMS, Vol. 54 No. 11, pp. 1861–1875.

Yadav, N. (2014), "Total interpretive structural modelling (TISM) of strategic performance management for Indian telecom service providers", *International Journal of Productivity and Performance Management*, Emerald Group Publishing Limited, Vol. 63 No. 4, pp. 421–445.

Yan, T. and Dooley, K. (2014), "Buyer–supplier collaboration quality in new product development projects", *Journal of Supply Chain Management*, Wiley Online Library, Vol. 50 No. 2, pp. 59–83.

Yang, C.-C. and Chen, B.-S. (2006), "Supplier selection using combined analytical hierarchy process and grey relational analysis", *Journal of Manufacturing Technology Management*, Vol. 17 No. 7, pp. 926–941.

Yang, C.-L., Lin, R.-J., Krumwiede, D., Stickel, E. and Sheu, C. (2013), “Efficacy of purchasing activities and strategic involvement: an international comparison”, *International Journal of Operations & Production Management*, Emerald Group Publishing Limited, Vol. 33 No. 1, pp. 49–68.

Yazici, H.J. (2012), “Buyer perceptions on the buyer-supplier collaborative relationship and performance: a service example”, *International Journal of Services and Operations Management*, Inderscience Publishers Ltd, Vol. 12 No. 2, pp. 165–187.

Yeniyurt, S., Henke Jr, J.W. and Yalcinkaya, G. (2014), “A longitudinal analysis of supplier involvement in buyers’ new product development: working relations, inter-dependence, co-innovation, and performance outcomes”, *Journal of the Academy of Marketing Science*, Springer, Vol. 42 No. 3, pp. 291–308.

Yilmaz-Börekçi, D., İşeri Say, A. and Rofcanin, Y. (2015), “Measuring supplier resilience in supply networks”, *Journal of Change Management*, Taylor & Francis, Vol. 15 No. 1, pp. 64–82.

Yilmaz-Börekçi, D., Say, A.İ. and Rofcanin, Y. (2014), “Measuring Supplier Resilience in Supply Networks”, *Journal of Change Management*, Taylor & Francis, No. ahead-of-print, pp. 1–19.

Zhang, X., Deng, Y., Chan, F.T., Adamatzky, a. and Mahadevan, S. (2014), “Supplier selection based on evidence theory and analytic network process”, *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, doi:10.1177/0954405414551105.

Zhao, Y., Cavusgil, E. and Cavusgil, S.T. (2014), “An investigation of the black-box supplier integration in new product development”, *Journal of Business Research*, Elsevier, Vol. 67 No. 6, pp. 1058–1064.

Zhou, K.Z., Zhang, Q., Sheng, S., Xie, E. and Bao, Y. (2014), “Are relational ties always good for knowledge acquisition? Buyer–supplier exchanges in China”, *Journal of Operations Management*, Elsevier, Vol. 32 No. 3, pp. 88–98.

Zhu, K.-J., Jing, Y. and Chang, D.-Y. (1999), “A discussion on extent analysis method and applications of fuzzy AHP”, *European Journal of Operational Research*, Elsevier, Vol. 116 No. 2, pp. 450–456.

Zouggari, A. and Benyoucef, L. (2012), “Simulation based fuzzy TOPSIS approach for group multi-criteria supplier selection problem”, *Engineering Applications of Artificial Intelligence*, Elsevier, Vol. 25 No. 3, pp. 507–519.

Appendix

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Survey Questionnaire

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Dear Sir/ Madam,

This is a questionnaire aimed to collect experts' opinions regarding supplier development practices in the manufacturing industry arena and draw fruitful insights for competitive strategies. Academic researchers, consultants and companies have proposed various aspects to be focused for effective implementation of Supplier Development Programs (SDPs). A questionnaire is framed along these aspects to explore more about their contribution in conducting the SDPs. Attempt in this study is intended to supplement a manufacturer with the guidelines for focusing on prime necessities while implementing SDPs and in turn establish strong supply network. The questionnaire is divided in to different parts namely, Supplier Development Enablers, Supplier Development Impediments Preferred Customer Enablers, and Preferred Supplier Enablers. Under each part, a list of attributes are floated after carrying out lot of background work. On the basis your experience please give your valuable opinions and help us in strengthening Indian supply networks. Also, please give the details your key suppliers/ group of similar type of key suppliers whom you are developing and fill the questionnaire with reference to your choice. The collected information will be purely used for carrying out the academic research work. The details of the study can be furnished on request from Mr. C V Sunil Kumar, BITS Pilani, Pilani Campus (cvenkata_sunil@yahoo.com) and Prof. Srikanta Routroy, BITS Pilani, Pilani Campus (srikantaroutroy@gmail.com) who are conducting the current research.

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General Information

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Company's name:

Name of respondent (optional):

Respondents Designation:

Experience in the present Industry:

Experience in the Industry (present and past):

1. How do you count your company as ________ (choose one)?

   a. Small enterprise (turnover about 100 Crores)

   b. Medium enterprise (turnover between 100 Crores to 1000 Crores)

   c. Large enterprise (turnover above 1000 Crores)

2. In which manufacturing sectors does your company fall (choose one)?

   a) Automotive b) Electrical and Electronics c) Aerospace

   d) Industrial Equipment e) Energy equipment f) Food, Beverage

   g) Materials & Construction h) Metals and mining i) Pharma, Biotech

   j) Others ______________________.

3. Please specify the major product(s) of your company.

   Major product(s) manufactured:

Major service(s) provided:

4. Do you have supplier development team in your company?

   a) Yes b) No c) Will set up in future

5. How SDPs are implemented in your organization? (Please brief your goals and objectives)

6. What is the position of your firm in implementing SDPs (choose one)?

   a) Nascent b) Learning

   c) Implementation d) Established

   e) Others (Specify)_____________________.

7. How do you perceive overall performance of your SDPs (choose one)?

   a) Unsatisfactory b) Satisfactory

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Guidelines for filling the questionnaire

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- Please consider each driver in isolation/standalone (individually) to improve SDP performance in Indian industry.
- Indicate/assign the actual level of importance of the construct as per your expertise.
- The level of importance is on 1 to 5 scale:
  1: Strongly disagree 2: Disagree 3: Neutral 4: Agree
  5: Strongly Agree

Part - I Questionnaire on SDEs

Manufacturer's response in SD (MRSD)	**1**	**2**	**3**	**4**	**5**
Emphasis is put on suppliers' standards and accordingly disparity is shown in the selection and development. **(MRSD1)**					
From time to time the suppliers' performances are measured and their areas of improvement conveyed. **(MRSD2)**					
Resource spend is optimized among the suppliers depending upon their performance. **(MRSD3)**					
Competition among the suppliers is spurred by differentiating in the order giving, processing and relationship development. **(MRSD4)**					
Requisite strategies are chalked out with different suppliers in view of supplier conflict and risk management. **(MRSD5)**					
Manufacturer favorably approves the cost saving changes recommended by its suppliers. **(MRSD6)**					
Buyer-Supplier collaborative efforts (BSCE)					
Workforce on buyer-supplier sides are clearly aware of the SD significance and its objectives. **(BSCE1)**					
SD investments, processes, outcomes and improvement shares are closely monitored and reviewed by top management. **(BSCE2)**					
Buyer-supplier incompetencies, capabilities, opportunities, threats and requirements are well-known to each other. **(BSCE3)**					
Experience, expertise, knowledge, skills, technology and innovation flows are seen between buyer-supplier. **(BSCE4)**					
Systems approach is adopted between buyer-supplier along the supply chain dynamics. **(BSCE5)**					
Workforce on buyer-supplier sides are empowered, keen, satisfied and for bearing in the transactions. **(BSCE6)**					
Supplier Development Practice and Reach (SDPR)					
SD initiatives are proposed and agreed with respect to the supply chain and competitive strategies of the stakeholders. **(SDPR1)**					
SD initiatives are proactively planned and executed in view of achieving permanent and long term solutions. **(SDPR2)**					
Cross functional teams are formed and allotted to extract all-round value internally and from the suppliers. **(SDPR3)**					
SD performance evaluation and feedback collection systems are timed in practice. **(SDPR4)**					
SD initiatives are regularly updated with respect with respect to changing environment and customer expectations. **(SDPR5)**					
Supplier Motivation Strategies (SMST)					
Supplier awards and incentives are given to recognize, acknowledge and appreciate the supplier’s inputs. **(SMST1)**					
Profits and risks sharing mechanisms are devised in getting the buyer's initiatives implemented. **(SMST2)**					
Clear policies, rules and regulations are made to handle any issue against the company’s interest. **(SMST3)**					
Best of the industry practices are benchmarked and corresponding improvement strategies are derived. **(SMST4)**					
SD decisions are made professionally without any bias or pressure from any agency. **(SMST5)**					

Buyer-Supplier Understanding (BSUD)					
By virtue of trust component and other interests the buyer-supplier business transactions are fast, reliable and cost saving. **(BSUD1)**					
Buyer-supplier are well aware of intensity of loss or advantage their businesses have because of their actions. **(BSUD2)**					
Buyer-supplier strategic objectives, priorities and preferences are aligned with each other. **(BSUD3)**					
Communication channels for information exchange are established to see the flow of value addition. **(BSUD4)**					
Buyer-supplier processes are properly integrated besides protecting their respective interests. **(BSUD5)**					
Buyer-supplier uncertainties are reduced along with improved responsibility and availability from each other. **(BSUD6)**					
Supplier Position and Status (SPST)					
Suppliers are made complaint by inclusion of clauses (penalties and legal obligations) in the signed contracts and by technology watch. **(SPST1)**					
Supplier's resistance is reduced by offering certain favorable business terms and conditions and increased business expectancy. **(SPST2)**					
Supplier's supplier condition is often checked and monitored as it affects the supplier's quality. **(SPST3)**					
Local suppliers are usually preferred and developed to increase accessibility and reduce lead time and logistics costs incurred. **(SPST4)**					
Suppliers' history of projects completed and time taken to complete are considered as parameters for investments. **(SPST5)**					
Supplier reputation is adding more value to the product/ service offered by the manufacturer. **(SPST6)**					

Part – II Questionnaire on SDIs

SDIs from Supplier Side	**1**	**2**	**3**	**4**	**5**
Supplier's Reluctance to Manufacturer's Initiatives (SRMI)					
Suppliers are concerned and show diffidence to make changes in their traditional procedures. (**SRMI1)**					
Supplier are becoming complacent with the manufacturer's requirements and initiatives. **(SRMI2)**					
Suppliers are non-compliant and revert back to their same old procedures despite the manufacturer's insistence. **(SRMI3)**					
Suppliers perceive the manufacturer as exploitative and trying to extract more value for the money paid. **(SRMI4)**					
Suppliers are ignorant of the sensibility in the manufacturer's requirements. **(SRMI5)**					
Suppliers' Resource Incompetency (SRIP)					
Suppliers are incapable (financially and technologically) of accommodating changes in the manufacturer's requirements. **(SRIP1)**					
Suppliers are not responsive to cope up with the changing demands, business transformations and generate innovative competitive advantages. **(SRIP2)**					
Suppliers do not have knowledged (specific standards and practices) and skilled (scientific and strategic value addition) workforce. **(SRIP3)**					
Suppliers are reactive (temporary solutions) rather than proactive (permanent and long term solutions) in nature. **(SRIP4)**					
Suppliers have poor organizational learning curve and overly dependent on the manufacturer. **(SRIP5)**					
Suppliers take longer times in implementing the manufacturer's proposed initiatives and resort to increase the pricing structure. **(SRIP6)**					
Suppliers' Disengagement and Dissatisfaction (SDDI)					
Suppliers are more attractive to competitors and relatively offer less priority to the manufacturer in offering best of the inputs and services. **(SDDI1)**					
A large number of complaints and conflicts are arisen from the suppliers in implementing the manufacturer's initiatives. **(SDDI2)**					
Suppliers are dissatisfied with the contracts, length of the contracts and uncertainty in the future business from the manufacturer. **(SDDI3)**					
Suppliers are worried about the insufficient level of significance and approvals to their efficient and effective contributions. **(SDDI4)**					
Suppliers are concerned about the investment of resources from the manufacturer and its return on investments. **(SDDI5)**					
Suppliers are anxious about manufacturer's performance and its growth in the market share. **(SDDI6)**					
Ill effect of Suppliers' Supply and Demand (ISSD)					
Suppliers' inputs and services are shared by the competitors along with the manufacturer thereby uncertainties are increasing. **(ISSD1)**					
Suppliers' performance is unbalanced with the performance of its customer base. **(ISSD2)**					
Preference to the implementation of SD initiatives is affected with the suppliers' customer base. **(ISSD3)**					
Suppliers' supplier practices and standards are affecting the manufacturer's SD practice. **(ISSD4)**					
Manufacturer has to go through more liabilities with the suppliers' supply and customer base conditions. **(ISSD5)**					

SDIs on Manufacturer Side	1	2	3	4	5
Incorrect Supplier Selection and SD initiatives (ISSI)					
At times developed supplier becomes opportunistic and create risk in the manufacturer's SDPs. **(ISSI1)**					
Improvement in the selected suppliers' performance gaps were not of advantageous to the manufacturer. **(ISSI2)**					
Incorrect, complex and uneconomical SD initiatives are proposed to the suppliers for implementation. **(ISSI3)**					
SD initiatives are out of suppliers' capabilities and not in line with the suppliers' interests. **(ISSI4)**					
Suppliers are stressed up in implementing the SD initiatives and meeting the SD targets. **(ISSI5)**					
Employees do not have clear view regarding the manufacturer's requirements and SD initiatives. **(ISSI6)**					
Manufacturer's Poor Supplier Staking (MPSS)					
Purchasing is still considered as mundane function with no strategic importance attached to the suppliers. **(MPSS1)**					
Suppliers' role in the manufacturer's value addition are limited in fear of complete understanding/ leakage of intellectual property. **(MPSS2)**					
The relationship between the buyer and supplier is still of arm's length in nature in implementing the SD initiatives. **(MPSS3)**					
Poor coordination strategies are proposed and practiced for an effective supply management. **(MPSS4)**					
Manufacturer's Ineffective Systems of Operation (MISO)					
Lack of effective measurement systems to gauge suppliers' performances, extract gaps and set targets to achieve. **(MISO1)**					
Largely unexplored issues, risks and opportunities for improvement on the suppliers' side. **(MISO2)**					
Suppliers are not educated about the intensity of losses occurred to the manufacturer with their lapses in meeting the requirements. **(MISO3)**					
Suppliers do not know the basis of proposed improvement plans by the manufacturer and their associated advantages. **(MISO4)**					
Manufacturer's poor success rate and lack of suppliers' confidence in the implementation are affecting the proposed SD projects. **(MISO5)**					
Lack of Manufacturer's Affirmation to the Supplier (LMAS)					
Suppliers are lacking inspiration from the manufacturer due to its win-lose plans and practices. **(LMAS1)**					
Extensive credit based business are in practice with the suppliers which in turn are hindering the suppliers' turnover. **(LMAS2)**					
Finished goods inventory is left for longer timer times at the suppliers' site levying capital cost and maintenance costs. **(LMAS3)**					
Payments made to the suppliers are linked with the unsure form of future orders with manipulative motives. **(LMAS4)**					
Poor investments of resources and suppliers' surplus offered by the manufacturer are provided in the SD processes. **(LMAS5)**					
Lack of suppliers' training, involvement and empowerment in the SD value addition process. **(LMAS6)**					

SDIs from both sides	1	2	3	4	5
Poorly Connected Manufacturing Systems (PCMS)					
Buyer-supplier have longer waiting times in getting the orders processed and the issues resolved. **(PCMS1)**					
No preferential relationships are extended between the buyer-supplier in ascribing the priorities. **(PCMS2)**					
Increased number of buyer-supplier conflicts with variegated interests. **(PCMS3)**					
Lack of strength in buyer-supplier relationships to have best supply chain flows transferred. **(PCMS4)**					
Buyer-supplier have increased costs related to quality and inspection. **(PCMS5)**					
Buyer-supplier personnel have poor awareness regarding the criticality and utility of the supplies. **(PCMS6)**					
Insensitive and Unreliable Management Systems (IUMS)					
Buyer-supplier do not have updated systems of industry's best practices. **(IUMS1)**					
Buyer-supplier systems are not resilient and do not have appropriate mitigation strategies to deal with the uncertainties. **(IUMS2)**					
Essential predictive business analytics are not used to have proper directions for buyer-supplier. **(IUMS3)**					
Lack of flexibility in the mechanisms to rectify and improve the buyer-supplier management strategies. **(IUMS4)**					
Lack of buyer-supplier top managements' emphasis and support in the implementation of proposed initiatives. **(IUMS5)**					
Uncoordinated Systems of Resource Sharing (USRS)					
Buyer-supplier are demotivated/ unsatisfied with regards to the profits and risks shared. **(USRS1)**					
Reluctance in exploring, generating and materializing the innovative ways of value addition. **(USRS2)**					
Knowledge of advance technology and its practice are not mutually advocated. **(USRS3)**					
Complaints rather than commitment are expressed by buyer-supplier in implementing the SD initiatives. **(USRS4)**					
SD initiatives are perceived as additional costs rather than essential investments. **(USRS5)**					
Poor Buyer-Supplier Alignment (PBSA)					
Buyer-supplier relationships are stressed up in achieving cost reductions without giving due consideration for other quality characteristics. **(PBSA1)**					
Buyer-supplier have developed differences in their supply chain and competitive strategies. **(PBSA2)**					
Buyer and suppliers have attained customer base with diversified requirements. **(PBSA3)**					
Proposed SD initiatives do not reflect win-win situations for buyer and suppliers. **(PBSA4)**					
Resource development made is not in line with the mutual interests, goals and objectives. **(PBSA5)**					
Oppressed and Limited Work Force (OLWF)					
Stressful rather than enthusiastic working environment is provided for the employees to take part in SD. **(OLWF1)**					
Lack of confidence instilled in the workforce regarding their growth and the growth of the company in relation to SD. **(OLWF2)**					
Lack of encouragement and empowerment provided for the workforce to contribute in SD. **(OLWF3)**					
Qualified personnel are not recognized, developed, and given secured engagement in SD. **(OLWF4)**					

Machinery and technology are given more importance than to the people who can drive them. **(OLWF5)**					

SDIs from external side	**1**	**2**	**3**	**4**	**5**
Risk Prone Manufacturing Systems (RPMS)					
Systems designed are made more industries' dependent that disruptions in other are impacting the general course of SD programs. **(RPMS1)**					
Manufacturing systems are not made adaptable with minimum emphasis on mitigation strategies. **(RPMS2)**					
Risk distribution is not optimally distributed among the systems. **(RPMS3)**					
Enough time phase is not created for the systems to respond to the disruptions. **(RPMS4)**					
Poor design of mitigation strategies are absorbing more efforts rather than effectively making the system resilient. **(RPMS5)**					
Necessary alternative strategies are not explored and developed so as face the disruptions. **(RPMS6)**					
Unscrupulous Internal and External Agents (UIEA)					
Political scenario is bringing in increased obligations to fulfill in contrast to the usual business conducts. **(UIEA1)**					
Unbiased decisions regarding supply chain flows are not made due to political pressures/ corruption/ to safeguard against the violations. **(UIEA2)**					
The practice of sacrificing transparency is spread with no healthy foundations laid out in the business conducts. **(UIEA3)**					
False means and provocation of false competitive advantages are diluting the healthy practice and competition in the market. **(UIEA4)**					
False allegations made/ adulteration in the products/ services offered are affecting the brand value, reputation and normal course of action. **(UIEA5)**					
Increased Competition and Scarcity in Resources (UCSR)					
Stringent rules and regulations on the utilization of resources are constraining the application of SD. **(UCSR1)**					
Increased competition for the same type of inputs is posing challenges for SD in terms of causing price and shortage pressures. **(UCSR2)**					
Differential treatments are brought in offering the inputs and services when buyer-supplier have to prioritize. **(UCSR3)**					
Buyer-supplier are forced to incur inventory holding costs/ have to increase lead time regardless of SD. **(UCSR4)**					
Unpredictable and Uncertain Supply Chains (UUSC)					
Changes in the support extend/ taxes and tariffs levied/ amendments made by various levels of governments are affecting SD course. **(UUSC1)**					
Buyer-supplier are facing loss of investments due to unforeseen advancements occurring at various fronts. **(UUSC2)**					
Compressed product life cycles are throwing challenges to buyer-supplier to streamline various SD activities. **(UUSC3)**					
Customers are more informed, attracted by alternatives and demanding to whom SD is to be aligned. **(UUSC4)**					

Buyer-supplier have to experiment out and invest in new methods and technologies whose impact is unknown. **(UUSC5)**					
Unusual and Unstable Regions of Operation (UURO)					
Poorly connected, improper, longer and expensive ways of transportation are obstructing SD effect. **(UURO1)**					
Buyer-supplier are confronted with less feasibilities to conduct mutual visits for essential exchanges in the value addition. **(UURO2)**					
Region of inflexible and/ or incapable and/ or demanding people as employees across buyer-supplier are affecting the SDPs. **(UURO3)**					
Agitated regions with numerous conflicts due to various differences such as race, region, religion, caste, and faction are affecting the SDPs. **(UURO4)**					

Part – III Preferred customer questionnaire

Efficiency in the Supply Chain Flows to the supplier (ESCF)	**1**	**2**	**3**	**4**	**5**
Manufacturer's payments made to the suppliers are motivationally triggered and prompt towards betterment in the suppliers' cash flow cycles. **(ESCF1)**					
Money flow from the manufacturer to the suppliers is transparent, virtuous and compensating in nature. **(ESCF2)**					
Suppliers are supported with definite reasonable resources, rights and returns for the supplier innovation to happen. **(ESCF3)**					
Manufacturer is efficient in pulling its inventory without costing the suppliers to bear inventory holding costs. **(ESCF4)**					
Suppliers are adequately and timely involved, their opinions are sought and are deciphered with right information through the decision making processes. **(ESCF5)**					
Suppliers are empowered and given flexibility to utilize manufacturer's resources depending upon the uncertainties encountered and complexity involved. **(ESCF6)**					
Motivational Aspects Experienced by the Supplier (MAES)					
Manufacturer timely, anticipatorily and transparently deals with the suppliers and awards (or) guarantees definite percentage of business. **(MAES1)**					
Win-win coordination strategies are proposed by the manufacturer yielding better turnovers and profits shared with the suppliers. **(MAES2)**					
Manufacturer actively and favorably provides cost reduction and improvement opportunities generated for the suppliers. **(MAES3)**					
Suppliers are appropriately recognized through various stimulating mechanisms with regards to their contributions. **(MAES4)**					
The competitive advantages gained from the suppliers are actively endorsed and promoted by the manufacturer. **(MAES5)**					
Manufacturer is favorably disposition with the key and deserving suppliers and in turn strategically directs its investments. **(MAES6)**					
Manufacturer's Efficient and Effective Program (MEEP)					
Manufacturer's transactions with the suppliers are simple, specific, faster, visible and mostly automated. **(MEEP1)**					
Manufacturer's requirements and changes if any are systematically, responsively and accurately defined and timely communicated to the suppliers. **(MEEP2)**					
Probable conflicts that arouse are thoroughly analyzed and acceptable resolutions are established by the manufacturer. **(MEEP3)**					

Suppliers' requirements, interests, concerns and contentment are timely identified and addressed by the manufacturer. **(MEEP4)**					
Optimal systems for supplier selection, evaluation and development are practiced by the manufacturer. **(MEEP5)**					
Manufacturer's Attractive Business Conduct (MABC)					
Manufacturer is characterized by order winning criteria, history and also responsive in adapting to the changing market requirements. **(MABC1)**					
Effective and efficient in achieving and aligning its competitive strategies with supply chain strategies in meeting its customer requirements. **(MABC2)**					
Manufacturer has commendable position, market share and growth, global presence in the industry. **(MABC3)**					
Manufacturer relatively has improved availability of its products and services and on the other hand has stable demand and profits. **(MABC4)**					
Effective in planning (strategies and decision making), communicating and directing its resources towards its targeted mission and vision statements. **(MABC5)**					
Manufacturer's products and services are competitive with certain brand value, proper market segmentation and adequate product variety. **(MABC6)**					
Manufacturer's Stability, Capability and Development (MSCD)					
Excellent in knowledge management and is capable of capturing and adopting advanced business trends, methods, processes and practices. **(MSCD1)**					
Manufacturer is responsible, compliant and emphatic about the business ethics, social behavior and environmental conscious manufacturing practices. **(MSCD2)**					
Manufacturer has well established flexible manufacturing systems for reengineering the products and services along with proper supplier management. **(MSCD3)**					
Manufacturer has stable top management team driving excellence in the business processes and instilling essential confidence among the stakeholders. **(MSCD4)**					
Effective strategies and decisions are proactively made; essential emphasis and support are extended to the stakeholders by the manufacturer. **(MSCD5)**					
Manufacturer is specialized in the core competencies and have sustainable competitive advantages developed. **(MSCD6)**					
Manufacturer is a well-known company for its competencies and is capable of generating innovation through its stakeholders. **(MSCD7)**					
Manufacturer-supplier Collective Engagement (MSCE)					
Manufacturer-supplier mutually interacts, visit and arrive at consensus in the problem definition, plan of execution, implementation and improvement. **(MSCE1)**					
Manufacturer-supplier has competitive learning curves and has aggressively reduced cost structures. **(MSCE2)**					
Manufacturer-supplier has well developed trust and in turn has faster and reliable transactions owing for win-win situations. **(MSCE3)**					
Manufacturer-supplier has strategic investments made in each other in order to meet their business requirements. **(MSCE4)**					
The top to bottom line workforce have conducive environment established to smoothly carryout the manufacturer-supplier transactions. **(MSCE5)**					
The decisions made at manufacturer-supplier are systematic, scientific and professional without jeopardizing the stakeholders' interests. **(MSCE6)**					
Manufacturer-supplier have standardized processes and practices in compliance with the industry standards. **(MSCE7)**					

Part – IV Preferred supplier questionnaire

Supplier's Response to Manufacturer's Requirements (SRMR)	**1**	**2**	**3**	**4**	**5**
Supplier is considerate about the profit and loss incurred by the manufacturer because of its supplies. **(SRMR1)**					
Supplier is sensible and consistent in its pricing structure for the manufacturer. **(SRMR2)**					
Supplier's supplies and services are highly satisfying to the manufacturer (in terms of better costs, features and the percentage of outsourcing). **(SRMR3)**					
Manufacturer has relatively less risks prone, uncertainties to endure, and conflicts to manage with is supplier. **(SRMR4)**					
Supplier is relatively more transparent and amicable to the manufacturer's requirements. **(SRMR5)**					
Supplier's supplies and services are made available when required by the manufacturer. **(SRMR6)**					
Supplier is more ethical and adherent to the policies and interests of the manufacturer. **(SRMR7)**					
The nature of supplier's supplies are made significant, strategic, critical and highly valued for the manufacturer. **(SRMR8)**					
Supplier's Compatible Manufacturing Systems (SCMS)					
Supplier has sustainable systems, products and processes used in the manufacturing. **(SCMS1)**					
Supplier is industry, societal and environmental health conscious and adopts sustainable manufacturing practices and standards. **(SCMS2)**					
Supplier has positive feedback in the industry and is well known for the supplies and services in the industry. **(SCMS3)**					
Supplier's supplies, services and practices attract manufacturer's end customers' preferences and contribute to their satisfaction. **(SCMS4)**					
Supplier is compliant to the manufacturer's certification standards and requirements and are recognized in this regard. **(SCMS5)**					
Manufacturer is relatively at ease in ordering and receiving the supplies and in getting its requirements fulfilled with less discrepancies. **(SCMS6)**					
Supplier's Potential for Manufacturer's Furtherance (SPMF)					
Supplier is effective and efficient in adopting to the manufacturer's essential change management and improvement strategies. **(SPMF1)**					
Supplier is resilient and capable of mitigating the supply chain uncertainties and disruptions and is effective to support the manufacturer. **(SPMF2)**					
Supplier is capable of developing innovative and competitive featured supplies and services for the manufacturer. **(SPMF3)**					
Supplier is accessible to the manufacturer with thorough communication, feedback and learning systems established. **(SPMF4)**					
Supplier is having stronger backward integration with its suppliers so as to support the manufacturer. **(SPMF5)**					
Supplier is having visionary top management to make right investments in the capacity development. **(SPMF6)**					
Supplier is having capable and firm organizational structure as well as learning systems to competitively put through the manufacturer's requirements. **(SPMF7)**					
Manufacturer is at ease to transfer essential resources for development and follow-up the returns on investment. **(SPMF8)**					

Supplier's Preferential Support to a Manufacturer (**SPSM)**					
Supplier is favorably dispositioned which in turn gets the manufacturer the best of resources and supplies transferred. (**SPSM1)**					
Conflict resolution mechanisms in the buyer-supplier transactions are best affected through mutual trust and for fulfilling mutual interests. (**SPSM2)**					
Buyer-supplier relationship is evolved over a period of time with clear understanding of mutual requirements. (**SPSM3)**					
Supplier turnout to the manufacturer's calls responsively and offers favorable supplies and services to the manufacturer. (**SPSM4)**					
Responsive in assisting a manufacturer by adopting and adapting to the changing manufacturing industry trends, methods, technologies and standards. (**SPSM5)**					
Supplier is effective in generating cost and time saving opportunities for the manufacturer. (**SPSM6)**					
Transaction and execution costs with the supplier is relatively less for the manufacturer. (**SPSM7)**					
Supplier Strategic Alignment with the Manufacturer (SSAM)					
Supplier operates through proactive manufacturing systems with improved productivity from the resources. **(SSAM1)**					
Supplier has dedicated resource development in view of meeting long term business requirements with the manufacturer. **(SSAM2)**					
Supplier has been aptly integrated to meet the strategic requirements of the cross functional departments at the manufacturer. **(SSAM3)**					
Supplier takes responsibility on the supplies and services provided to the manufacturer. **(SSAM4)**					
Supplier plans and executes in meeting specific requirements of the manufacturer with a view of long term relationship. **(SSAM5)**					
Supplier offers relatively less resistance to mutual visits, meetings and changes proposed by the manufacturer. **(SSAM6)**					
Supplier is well aware of manufacturer's business plans, actions, goals and objectives which in turn meet the manufacturer's requirements. **(SSAM7)**					
Inbuilt flexibility to incorporate product and process design changes, demand fluctuations and aligns with the manufacturer's product life cycles. **(SSAM8)**					

Brief Biography of the Supervisor

SRIKANTA ROUTROY has received Bachelor of Technology in Mechanical Engineering from College of Engineering and Technology, Bhubaneswar and Master of Technology in Industrial Engineering and Management from IIT, Kharagpur. He has completed his PhD in the area of supply chain management from Birla Institute of Technology and Science (BITS), Pilani in April 2005. At present, he is working as an Associate Professor (Mechanical Engineering Department) in Birla Institute of Technology and Science Pilani, Pilani Campus. He has more than sixteen years of teaching experience. He has reviewed fives books on supply chain management and operations management. He has authored and co-authored more than 58 research papers in refereed national (16) and international journals (42), and National and International Conferences (28). He has been a reviewer of many Journals of International repute like European Journal of Operational Research; Production Planning and Control, Industrial Management & Data Systems; Supply Chain Management: An International Journal, Benchmarking: An International Journal. His name was listed in Marquis "Who's Who in the World", 2008-2012 (25th -29th Edition). His broad areas of research interest lie in supply chain management, supplier development, green supply chain management, agricultural supply chain management, health care supply chain, lean manufacturing, agile manufacturing, evolutionary optimization techniques and Multi-Criteria Decision Making (MCDM) methods. He has guided one PhD and currently three PhD students are working with him. He has guided 15 ME Theses and 20 BE (dual degree) Theses.

Brief Biography of the Candidate

C.V. SUNIL KUMAR has received a Bachelor's of Technology in Mechanical Engineering from Intell Engineering College, Andhra Pradesh and a Master's of Engineering in Manufacturing Systems Engineering from BITS Pilani, Pilani Campus. Currently, he is pursuing a PhD in supply chain management (in the Mechanical Engineering Department) at BITS Pilani, Pilani Campus. His PhD was supported through UGC sponsored major research project [Research Project No. 42-892/2013 (SR)] entitled "Design of Supplier Development Implementation Framework for Indian Manufacturing Industries". Under the UGC project, he was a Junior Research Fellow (JRF) for two years and was promoted as a Senior Research Fellow (SRF) in the year 2016. His research interests are in supplier development, supply chain management, systems simulation modeling and analysis.

Research Publications

International Journal articles (Peer-reviewed) published/accepted

1. Sunil Kumar C V and Srikanta Routroy (2016), "**Case Application of a Methodology for Determining a Manufacturer's Preferred Customer Status with Suppliers**", *Engineering Management Journal*, Vol. 28 No. 1, pp. 25-38.
2. Sunil Kumar C V and Srikanta Routroy (2016), "**Analysis of Preferred Customer Enablers from Supplier's Perspective**", *Business Process Management Journal*, Vol. 22 No. 6, Accepted for Publication.
3. Sunil Kumar C V and Srikanta Routroy (2016), "**An Approach to Address Principal Supplier Development Impediments**", *Benchmarking: an International Journal*, (Accepted).
4. Sunil Kumar C V and Srikanta Routroy (2016), "**An Approach for Measuring a Manufacturer's Preferred Supplier Status**", *Asia Pacific Journal of Marketing and Logistics*, Vol. 28 No.5, Accepted for Publication.
5. Sunil Kumar C V and Srikanta Routroy (2016), "**Performance Analysis of Supplier Development Programs**", *Benchmarking: an International Journal*, Vol. 24 No. 4, Accepted for Publication.
6. Sunil Kumar C V and Srikanta Routroy (2016), "**Analysis of suppliers' preferences to a manufacturer using Kano model and performance value analysis**", *International Journal of Business and Systems Research*, Accepted for Publication.
7. Sunil Kumar C V and Srikanta Routroy (2015) "**Demystifying Manufacturer Satisfaction through Kano Model**", *Materials Today: Proceeding*, Vol. 2 No. 4/5, pp. 1585-1594.
8. Srikanta, Routroy and Sunil Kumar, C V (2014), "**Analyzing Supplier Development Program Enablers using Fuzzy DEMATEL**", *Measuring Business Excellence*, Vol. 18, No. 4, pp. 1-26.
9. Srikanta, Routroy and Sunil Kumar, C V (2014), "**Strategy for Supplier Development Program Implementation: A Case Study**", *International Journal of Services and Operations Management*, Vol. 21 No. 2, pp. 238-264.
10. C V Sunil Kumar and Srikanta Routroy (2014), "**Addressing the Root Cause Impediments for Supplier Development in Manufacturing Environment**", *Procedia Engineering*, Vol.97, pp. 2136–2146.

Papers under review

1. Measuring Interdependencies of Preferred Supplier Enablers
2. Supplier Development Furtherance Model in Indian Manufacturing Industry.
3. Modeling Supplier Development Barriers in Indian Manufacturing Industry.
4. Modeling Preferred Supplier Relationships in Indian Manufacturing Industry.
5. Modeling Preferred Manufacturing Customer Relationships in Indian Manufacturing Industry.

Papers in International Conferences

1. Sunil Kumar C V and Srikanta Routroy (2016), "**Analyzing a manufacturer's returns from supplier development programs**", *5th International Conference of Materials Processing and Characterization*, (Accepted).
2. Sunil Kumar C V and Srikanta Routroy (2015), "**Supplier's Discretion for Preferred Manufacturer**", 3rd International Conference on Industrial Engineering (ICIE-2015) & 57th National Convention of Indian Institution of Industrial Engineering, SardarVallabhbhai National Institute of Technology, Surat, November 26 -28.
3. Srikanta Routroy and Sunil Kumar C V (2015), "**Modeling Interdependencies of Supplier Development Enablers**", 3rd International Conference on Industrial Engineering (ICIE-2015) & 57th National Convention of Indian Institution of Industrial Engineering, SardarVallabhbhai National Institute of Technology, Surat, November 26 - 28.
4. Sunil Kumar C V and Srikanta Routroy (2015), "**Demystifying Supplier Satisfaction through Kano Model**", First International Conference on Evidence Based Management 2015 (ICEBM 2015), 20th -21st March, BITS Pilani, Pilani Campus, pp. 638-644.