Frugal Innovation for Supply Chain Sustainability in SMEs: Multi-method Research Design

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Abstract

In this study we attempt to establish the missing links between supply chain sustainability and frugal innovation. Our study motivations stem from two facets of the emerging markets: firstly, the institutional barriers and secondly, the resource constraints. We argue that there is a synergy in the concepts of frugal innovation and sustainability in supply chains and there is a need to further explore this synergy. Furthermore, we claim that even in the wake of many success stories in the frugal innovative supply chain management practices from emerging markets such as India, there are very few, if any, attempts made to understand the implications of a sustainability oriented frugal innovations in the particular context. To address this gap we develop a model to establish the linkage between sustainable supply chains and frugal innovations. Our proposed conceptual framework depicts the hierarchy and interlinks of the identified enablers in developing sustainability oriented frugal innovative capabilities in supply chains. Furthermore, we have empirically validated our theoretical framework using survey data. We observed that most of the interpretive links are supported. These findings extend the understanding of frugal innovation for supply chain sustainability using multi-method research design, while also providing theoretically guidance to managers in the development of frugal innovation capability to achieve sustainability in supply chain in resource constrained environment.

Keywords: Frugal innovation, sustainability, sustainable supply chain, TISM, MICMAC analysis, confirmatory factor analysis (CFA), structural equation modelling (SEM)

1. Introduction

Sustainability is a major and growing driver of the business change (Childe, 2009; Seebode et al. 2012; Prahlad, 2012; Bendul et al. 2017; Rosca et al. 2017; Zhang et al. 2017). Its implications for innovation are clear- living and working in the populous world of scarce resources. The field of innovation and sustainability has attracted increasing attentions among academia and practitioners (Hopkins, 2009). Brem and Ivens (2013) argue that many organizations provide evidence that innovation and sustainability are closely linked. For instance, there are several global corporate giants looking for business expansion are giving more importance to expand their business to emerging markets such as India, China, and Brazil. Around 20,000 multinational corporate giants are operational now in emerging markets and they are expecting around 40% of their total revenue only from India and China (Eyring et al., 2011). However, for those organizations whose home base and / or strategic focus is on markets where customer demand and stakeholder pressure do not (yet) provide similar incentives, innovations tend to focus on frugal and reverse innovation as well as sustainability and its management (Brem and Ivens, 2013; Pisoni et al. 2018). For instance, small and medium enterprises (SMEs) in emerging markets such as India are now focusing more on frugal innovation (Ojha, 2014). Even in this high-tech era, one third of the world population is still in poverty out of which majority are in developing or undeveloped countries and thus there is immense potential to expand the business through innovation to serve this community (Fredriksson and Tommervik, 2014; Pisoni et al. 2018). According to Nidumolu et al. (2009), organizational and technological innovations are the mother lode of sustainability that will ensure bottom line and top-line revenue enhancement. Ongoing innovations are necessary to make the supply chain lean (Lamming, 1996; Lelah et al., 2012) and it will ultimately help to improve organizational performance (Hui et al., 2015). At the same time, organizations have to ensure that innovation in business and sustainability in operations are going hand in hand to support the society and in minimizing any possible environmental impact (Desai, 2012; Schaltegger and Wagner, 2011; Gold et al. 2013). According to Horn and Brem (2012), frugality and sustainability are the two major fields of future innovation management. However, Bhatti and Ventresca (2013), further argues that even definitions of frugal innovations are not still matured and further the available definitions are not backed by substantive theoretical or empirical work.

Despite of rich literature focusing on innovations in emerging markets (Drazin and Schoonhoven, 1996; Bhatti, 2012), the literature focusing on the compatibility of frugal innovations and sustainability are limited (Leach et al., 2012; Fagerberg et al., 2010). Innovation programs in organizations normally go with the assumption of affluence and abundance of resources, which may not fit for the resource limited conditions in developing and undeveloped economies (Prahalad and Mashelkar, 2010). Moreover, scholars (e.g. Winter and Knemeyer, 2013; Cheng et al., 2015; Subramanian and Gunasekaran, 2015; Bendul et al. 2017) argue that there is limited research in frugal and sustainable innovation methods in supply chains. Existing literature, have largely failed to provide theory focused and data driven research which can throw substantial light on frugal innovation in context to sustainability (Levanen et al. 2015;Cozzens and Sutz, 2014; Vang and Joseph, 2009). Many scholars argue, that the frugal innovation is an emerging area and there is a pressing need to have more rigorous empirical research in the field (Zeschky et al., 2011; Zeschky et al., 2014).

First, most of the literature on the different aspects of getting the advantages of innovation to improve sustainability especially in the context of larger organizations but not in supply chains and SMEs (see, Smith et al., 2010; Leach et al., 2012; Jacobsson and Bergek, 2011; Bendul et al. 2017). Second, most of the empirical studies in context to supply chains in SMEs are anecdotal.

In order to advance knowledge on frugal innovation for supply chain sustainability in context to SMEs, this study contributes to the development of theoretical framework. The development of the theoretical framework was conducted using multi-method research design that encompasses interviews, content analysis of secondary data, and survey using structured questionnaire. This study is one of the first studies that develop a multidimensional and complementary conceptualization of frugal innovation for supply chain sustainability in SMEs. The empirically validated frugal innovation for supply chain sustainability, will be useful for future research on frugal innovation for supply chain sustainability, while providing a measurement scale for organizations to assess their current frugal innovation practices to identify the area of improvement.

The remainder is structured as follows. The next section discusses the concepts of frugal innovation, sustainability and the enablers of sustainability frugal innovation in supply chain. Ten enablers selected are explained in each subheading with detailed evidences from literature body. The third section outlines the methods used in the study. It follows the conceptual framework development process and analysis using TISM technique followed by its empirical validation. The fourth section present the discussion based on results and further outline our contributions to theory and practice. Finally, we conclude our study with limitations and further research directions.

2. Underpinning Theories

Lewin et al. (2004) argues that both institutional theory (IT) and resource based view (RBV) link the organization to the macro environment. Oliver (1997), further argues that institutional theory provides better understanding of complex process by which firms make resource choices. Moreover, Bloodgood and Morrow (2000), in the line of Oliver's (1997) arguments, suggest that the integration of IT and RBV, may provide better understanding of the resources selection made by the firms. Bhatti and Ventresca (2013) further argues that the use of IT and RBV, may provide better understanding of the innovation activities and its linkage to the institutional environment and to the resources available therein.

Stiglitz (2001) argues that all societies are resource-constrained and poor countries even more so. However, Stiglitz (2001) further suggests that on top of the general resource constraints faced by emerging countries are the constraints on the capacity of government to deal with the number of issues it can pursue, again pointing back to institutional voids. Despite nuanced understanding of the development literature of the double edged problem of institutional voids and resource scarcity, there is scant work on how frugal innovation takes place within both simultaneous challenges.

2.1 Institutional theory (IT)

According to DiMaggio and Powell (1983), organizations are becoming similar in its nature mainly because of three types of institutional pressures such as coercive, mimetic and normative. Thus according to institutional theory, the performance and outcomes of organizations are influenced by external institutions (Mizruchi and Fein, 1999). Government rules and regulations, socio political situation, market trends, and competition are some of these institutions (Law and Gunasekaran, 2012). In supply chain management, IT has become one of the very popular and well accepted theories (see, Ketokivi and Schroeder, 2004; Liu et al., 2010). Government funding, government policies and regulations, international rules and regulations, social values and ethics and competition are the external factors that we have considered in the study that may drive the sustainability oriented innovations in supply chain based on the institutional theory perspective.

2.2 Resource based view theory (RBV) and Knowledge based theory (KBV)

RBV argues that any firm can acquire a competitive advantage over its rivals by making the resources of that organization very distinctive or superior compared to the resources of its competitors provided that the resource requirements are exactly in match with the environmental opportunities and business requirements (Andrews, 1971; Thompson and Strickland, 1990). According to RBV, an organization can be considered as a bundle of resources consisting of tangible and intangible assets and tacit knowledge (Barney, 1986). Many researchers have explored innovation frameworks based on resource based view theory (see, Aboelmaged, 2014; Adebanjo et al., 2017; Laosirihongthong et al., 2014) and knowledge based view theory (Alexander and Childe, 2013). Process design capability, supply chain talent, infrastructure quality & connectivity, environmental awareness, knowledge and Technology are the key enablers that we have considered in the study which may influence the sustainability oriented innovations in supply chain.

The KBV –an extension of RBV– argues that knowledge is one of the strategic resources which may be the source of competitive advantage (Grant, 1996). The effective management of knowledge, hence, leads to better performance in innovative activities, such as new product development (Ettlie and Pavlou, 2006) and leads to organizational transformation (Zahra and George, 2002). Within developing countries, firms that follow the paradigm of frugal innovation aim at achieving extreme cost advantage (Zeschky et al., 2011). Developing affordable products and services is critical for SMEs in this context, and to this extend the role of knowledge management is important. Knowledge management, according to Alegre et al. (2011), involves "identifying and leveraging the collective knowledge in an organization to contribute to its performance" (p. 2). Utilizing and managing effectively knowledge can enable SMEs to overcome problems related to the product and service development and develop sustainable businesses (Durst and Edvardsson, 2012). Cohen and Levinthal (1990) have argued for the reliance of firms that innovate on their knowledge capabilities, whereas Zahra and George (2002) suggested that it is absorptive capacity –being a capability for processing knowledge– that enhances innovation. In later studies, Von Krogh (1998) acknowledged the importance of mobilizing knowledge resources and turning them into value-adding activities, linking thereby knowledge management to innovation and subsequently innovation performance. Such a view was adopted in recent studies (e.g. Alegre et al., 2011; Bagnoli and Vedonato, 2014).

2.3 Sustainability

Sustainability can be defined as a quality that helps to preserve, save and keep and having three widely accepted components such as environment, society and economy (Ciceri, 2010; Garbie 2014; Carter and Easton, 2011). Sustainability can assist organizations in gaining competitive advantage (Luthra et al., 2015; Preuss, 2007). Kleindorfer et al. (2005) asserted that sustainable operations management (SOM) practices have a positive impact on the economic performance of organizations and support to minimize the adverse impacts on society and environment. According to Gotschol et al. (2014) internal environmental programs within organizations have a positive impact on the economic, environmental and social performance of an organization, because any investment in environmental management programs helps to gain economic benefits for companies in their long run. Organizations must consider the term 'green' as a tool for achieving competitive advantage to go global and to increase the market share as today's highly educated and highly aware customers prefer eco-friendly products (Deif, 2011; Houe and Grabot, 2009). Social sustainability practices help organizations to achieve greater social reputation (Marshall et al., 2015). For instance, while from an economic perspective of sustainability, Woolworths Company succeeded to save 9.3 million US Dollars after focusing on ecological, social and economic indices based on triple bottom line initiative (Santos et al., 2014). Thus, we conclude that sustainability is necessary for the operations of an organization, realized through SOM techniques.

2.4 Frugal Innovation

Frugal innovation can be defined as the unique way of thinking and acting in response to challenges by effectively spotting the opportunities even in the worst circumstances and improvising the solutions resourcefully in the simplest possible way (Radjou et. al., 2012). The major challenge the companies may face in this regard is to inline their business processes and products to make the price of their products and services to a level where economically disadvantaged will also feel it as affordable. For instance, Aravind eye hospital serving .25 million poor people in India in every year is popularly known as the McDonald's of cataract surgery (Chaudhary et al., 2012). This frugal business model has demonstrated its quality, affordability, scale of business and sustainability. The treatment cost is 40$ at the max and to support this the hospital has low cost lenses manufacturing unit as well, which was then expanded into a global level. Another example of frugal supply chain system is the lunch box delivery system followed by 'dabbawalas' in Mumbai, India. According to Moore (2011), 'dabbawalas' follow a very complex supply chain system built up of complex series of delivery zones, multiple sorting points by using some custom made codes in local language with 99.999999 percent accuracy only by using bicycles and various modes of public transportation to deliver lunch box. Thus, business models that are more affordable to the poor of the poorest and that maintain the quality, volume and sustainability in its services and products need to be further investigated by OM research community.

Frugal innovations consider affordability as the major criterion and try to meet the basic necessities of poor by considering society as a whole and innovation becomes a development imperative (Birtchnell, 2011). Furthermore, frugal innovations consider resource and financial shortages which makes it best fit for even economic downtime periods (Soni and Krishnan, 2014; Ernst and Kamrad, 2000; Sharma and Iyer, 2012). Therefore, they are the base of grass root entrepreneurship with poor as consumers, co-producers and innovators (Pansera and Sarkar, 2016), contributing thereby to uplifting the living standards of poor while being socially responsible. According to Bhatti and Ventresca (2013) and Woolridge (2010), frugal innovations can also be considered as a way to grow with less and to cut costs, which in turn will boost environmental and economic performance of organizations. Hence, they support sustainability as: firstly, they are more energy or material efficient; secondly, they promote technologies that are more democratic; and thirdly, they are pro- poor and consider society as a whole (Leach et al., 2012; Fagerberg et al., 2010).

2.5 Enablers of frugal innovation for supply chain sustainability

Based on extensive review of literature, we summarize ten enablers of frugal innovation for supply chain sustainability in Table 1:

2.5.1 Government Funding (GF)

Availability of funds and financial support is necessary for sustainability initiatives. Without proper funding it is almost impossible to execute any such sustainable innovation initiative (Mudgal et al. 2010). Cooke (2001) emphasizes the importance of funding especially public funding for encouraging regional innovation and knowledge economy. Government funding is very critical in encouraging small and medium scale companies to adopt green initiatives in their supply chains (Lee, 2008). Thus, public funding is essential and is a vital facilitator in promoting innovation, sustainability and cleaner technology initiatives in supply chain and is considered in our study as one of the enablers.

2.5.2 Government policies & regulations (GPR)

There is literature suggesting that government policies and regulations is one of the major enablers of organization's sustainability initiatives (Georgiadis and Besiou, 2008; Gold et al., 2010; Kumar and Yamaoka, 2007; Zhu et al., 2005). External policies and regulations can enable innovations by compelling the organizations to adopt best in class technologies and process standards with deadlines that will boost sustainability performance (Henriques and Sadorsky, 1999; Porter and Van de Linde, 1995). Wycherley (1999) lists out government policies as one of the facilitators in greening the supply chain. Thus, we argue that government policies and regulations are important for enabling sustainable innovation initiatives.

2.5.3 Process design capability (PDC)

A business process is defined as a structured set of activities with specified business outcomes for customers (Davenport and Beers 1995). Holmstrom (1998) explains how business process innovations had become the key factor in vendor managed inventory implementation to impart sustainability and lean attributes to organization's supply chains. Customer Relationship Management (Croxton et al. 2001), Customer Service Management (Bolumole et al., 2003), and Returns Management (Rogers et al., 2002) are some of the key business processes that have direct impact on the performance of supply chain of an organization. Both improvement and integration of business processes are critical for organizational performance increasing revenue, reducing operating cost, reducing working capital, and increasing asset efficiency (Croxton et al., 2001; Lambert et al., 2005). Thus, process design capability is considered as one of the key enablers for sustainability oriented frugal innovations in supply chin.

Table 1: Enablers* of sustainability oriented frugal innovation in supply chain management

Serial Number	Enablers of sustainability oriented frugal innovation in supply chain	Source
E1	Government funding	Mudgal et al. (2010); Cooke (2001); Lee (2008)
E2	Government policies & regulations	Georgiadis and Besiou (2008); Gold et al. (2010); Kumar and Yamaoka (2007) and Zhu et al (2005)
E3	Process design capability	Croxton et al. (2001); Davenport and Beers (1995); Holmstrom (1998); Lambert et al. (2005)
E4	Supply chain talent	Giunipero et al. (2006); Lambert et al. (1998); Gammelgaard and Larson (2001)
E5	International rules & regulations	Ji et al. (2014); Plambeck and Wang (2009); Walker et al. (2008); Zhu and Sarkis (2006); Zhu et al. (2007)
E6	Social values & ethics	Gunasekaran and Spalanzani (2012); Drake and Schlachter (2008); Roberts (2003); Awaysheh and Klassen (2010); Kim (2009)
E7	Competition	Henriques and Sadorsky (1999); Liang et al. (2007); Dubey et al. (2015); Ferguson and Toktay (2006)
E8	Infrastructure quality & connectivity	Rai et al. (2006); Lowson et al. (1999); Frota Neto et al. (2008); Kim (2009)
E9	Environmental awareness & knowledge	Wu and Pagell (2011); Madsen and Ulhui (2001); Perron (2005); Mudgal et al. (2010)
E10	Technology	Yuksel (2008); Perron (2005); Spekman et al. (2002); Mohr and Nevin (1990); Dodgson et al. (2006)

* For the purpose of undertaking an unbiased analysis, each enablers of frugal innovation for supply chain sustainability was allocated a number from E1 to E10

2.5.4 Supply chain talent (SCT)

According to Dubey and Gunasekaran (2015), talent is an important factor in getting better support for sustainable supply chains. Hence, companies should focus on developing talented supply chain professionals for the success of sustainability initiatives. Ensuring smooth functioning, strategic cost reductions (Giunipero et al., 2006), collaborative innovation (Chapman & Corso, 2005) are very difficult without having talented supply chain professionals possessing strong technical, communication, and financial skills. Many researchers (Lambert et al., 1998; Gammelgaard and Larson, 2001; Zhang and Lv, 2015) strongly argued that supply chain talent development needs further conscious and planned effort from organizations. Thus we too have considered supply chain talent as one of the enablers of sustainability oriented frugal innovations in supply chain.

2.5.5 International rules & regulations (IRR)

European Union rules concerning, for instance, electrical and electronic equipment waste and the norms requiring vehicle manufacturers to guarantee the recycling of vehicle raw material up to a minimum of 85% are examples of international rules and regulations that will drive innovation and sustainability in supply chain (Ji et al., 2014; Plambeck and Wang, 2009).International environmental emission regulations not only encourage companies to reduce the emissions from their products but also compel them to invest in emission reduction technologies and innovation (Ji et al., 2014).There is rich literature arguing that international rules and regulations is a strong external factor driving the sustainability and innovations in supply chain (see Walker et al., 2008; Zhu and Sarkis, 2006; Zhu et al., 2007). Following these scholars, we also argue that international rules and regulations are considered as an important driver.

2.5.6 Social values & ethics (SVE)

According to Gunasekaran and Spalanzani (2012) business ethics is an important driver of sustainability initiatives. Especially ethical practices are important in the sourcing, purchasing and the successful collaboration of organizations in supply chain domain (Drake and Schlachter, 2008; Roberts, 2003).Responsible supply chain is becoming more relevant in this era of social turbulence and is attracting the more attention of researchers (see Awaysheh and Klassen, 2010; Kim, 2009). Hoejmose et al. (2013) further emphasize the need to include organizational strategies that aim at developing socially responsible supply chain processes. Thus we strongly argue to consider social values and ethics as one of the enablers.

2.5.7 Competition (CO)

According to Henriques and Sadorsky (1999), environmental technology leaders have the ability to set the environmental industry norms and drive sustainability innovations in supply chain. Competition is identified as one of the mimetic pressures from an institutional theory perspective since organizations try to capture the best sustainability and other innovative practices already successfully adopted by competitors (Liang et al., 2007; Dubey et al., 2015). Gaining competitive advantage is critical for all organizations (Ferguson and Toktay, 2006) and thus competition is becoming a major driving force in the implementation of any best practices in an organization. Therefore competition is included as one of the important enablers.

2.5.8 Infrastructure quality & connectivity (IQC)

Collaboration is possible with improved physical flow integration, which includes stocking and flow of materials and finished goods (Rai et al., 2006). Connectivity will indicate the level of transportation network and the easiness of movements between the nodes in the supply chain. Better infrastructure and connectivity will help for example to adopt just-in-time systems and to achieve cost effective transportation, warehousing, and logistics (Lowson et al., 1999). Transportation and logistics is the heart of any supply chain system and connectivity and infrastructure quality are the two parameters that directly affect this (Frota Neto et al., 2008; Kim, 2009). Thus, we conclude that infrastructure and connectivity is an external facilitator that drives the sustainability oriented innovations in supply chain.

2.5.9 Environment awareness & knowledge (EAK)

Environmental strategies have a direct impact on the supply chain and competitiveness of the organization (Wu and Pagell, 2011). According to Madsen and Ulhui (2001), there must be planned efforts in creating environmental awareness among the workforce for the successful implementation of sustainable supply chain initiatives through training and education. Scholars (Perron, 2005; Mudgal et al., 2010) argue that the lack of knowledge of SMEs on the benefits of environmental friendly initiatives on organizational performance is preventing them from achieving green products and processes. Thus, it is necessary to consider environment awareness and knowledge as an enabler of sustainability oriented frugal innovations in supply chain.

2.5.10 Technology (TA)

Cleaner technologies help improve both environmental and economic performance (Yuksel, 2008). According to Perron (2005), one of the major barriers to the sustainable supply chain institutionalization is the unavailability of latest technologies. The importance of technology for achieving competitive advantage (Spekman et al., 2002) and effective communication in supply chains (Mohr and Nevin, 1990) has been highlighted. Technology could also help to attain environmental friendly practices, to support open innovation (Dodgson et al., 2006) and to minimize the cost involved through frugal ideas. Thus, technology is considered as one of the enablers in our study.

3. Research Methods

Based on the conceptualization of frugal innovation for sustainability in supply chain, grounded in IT and RBV, we adopted a multi-method research design, including interviews, and survey, to empirically validate the theoretical framework for frugal innovation for supply chain sustainability. First, following Churchill's suggestion (Churchill, 1979), we have refined the validity and reliability of our measurement by adopting the measurement items that are previously studied or validated in previous studies related to enablers for frugal innovation for sustainability (see, Table 1 and appendix A for the constructs, measurement items and supporting literature). The extensive review of literature is complemented by 10 managers who are knowledgeable in the field of sustainable operations and frugal innovation to ensure the content validity of the enablers of the frugal innovation for sustainability in supply chain. To further ensure that the measurement adequately represent the real-life practices of organizations, we have conducted qualitative content analysis to identify the enablers of the frugal innovation for sustainability. Boyer and Swink (2008) argues that qualitative content analysis is a useful method to identify enablers which are useful in real-life practices. Secondary data was collected from the annual and corporate social responsibility (CSR) reports. Hence, we can argue that this approach helps overcome the limitation of literature review and in-depth interviews by improving the generalizability of the measurement scales. Secondary data also helps to eliminate concerns related to common method bias, complementing the survey based study (Gattiker and Parente, 2007; Chan et al. 2016). Although, Tangpong (2011) argues that content analysis can be questioned for its validity as the information collected via public sources. Such threat can be eliminated through triangulation by using in tandem with survey risk (Jick, 1979). Hence, in this study we have gathered primary data via survey to validate our frugal innovation for sustainability in supply chain constructs. The use of secondary and primary data is useful to improve the rigor of the study by allowing triangulations and to overcome common method bias that may occur due to single source of data (Boyer and Swink, 2008; Cameron and Molina-Azorin, 2011; Boon-itt and Wong, 2016).

3.1 Phase 1: Interpretive Logic (Delphi Study)

In Phase 1 of this research, we followed Warfield (1974) approach and conducted an exploratory qualitative research. Hence, we used Total Interpretive Structural Modeling (TISM) technique, a Delphi study (Sushil, 2012; Dubey et al. 2017). TISM in recent years has attracted growing attentions from the operations management scholars (see, Mangla et al., 2014; Mishra et al., 2017; Singh and Sushil, 2013; Srivastava and Sushil, 2014; Sushil, 2017; Dubey et al., 2015, 2017; Luo et al. 2017; Anbarasan and Sushil, 2018). According to Nasim (2011) and Sushil (2012), TISM has its own advantage over Interpretive Structural Modelling (ISM) because the causal relationships or transitive links between the constructs of the model are also well captured in the TISM model.

In TISM, as with ISM, group expert judgment methodology is used to understand the relationships among the studied variables (Vivek et al. 2008; Sushil, 2012, 2017). Opinions from academics and industry experts with rich experience in supply chain field were incorporated in the study using a structural self-interaction matrix (SSIM). Opinions from industry experts were further refined with the help of extensive literature review by ensuring that no variables are getting dropped or added up. Most of the experts were considering the role of government as a major factor in promoting the frugal innovations in supply chain management in a country or region (see Appendix A)

Twenty five exploitable responses were chosen from responses from around 30 experts with automotive SMEs in India in the supply chain domain with the help of social networking sites. The experts approached were having fifteen plus years with automotive SMEs in India or having strong academic credential with strong publication records in the supply chain domain. The response rate was 80%. Warfield (1974) and Malone (1975) were the first operation research experts, who introduced ISM technique. The major steps involved in TISM can be listed out in the sequence as: (Sushil, 2012; Dubey and Ali, 2014): Literature collection on the topic; review of collected literature to identify the variables; explaining the VAXO matrix allocation rules to the experts; formulation of structural self-interaction matrix (SSIM) (see Table 2) with the help of experts in the domain; Conversion of structural self-interaction matrix to a binary matrix and then to final reachability matrix by considering transitivity property. Deriving the total driving power and dependence based on the binary matrixes to find out the level of variables; and making the directed graph (DIGRAPH) based on the levels of variables identified. ISM model can be finalized by preparing a structural model from DIGRAPH, which will be self-explanatory on the relationship among the variables. Reviewing of the structural model may be required to validate the conceptual stability and make necessary changes in the model. There are two possible responses such as 'yes' or 'no' for any question regarding the relationship between two variables. And thus there will be nC_2 possible number of paired comparisons, which will tally into 45 for 10 variables in our case. The ISM model can be taken to the next level of TISM by incorporating the interpretive logic between the enablers based on the expert explanation. These interpretive logics are the contextual relationships among the variables which are derived through brainstorming.

Table 2: Structural self-interaction matrix of enablers (SSIM)

	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1
E1	V	V	O	O	V	V	V	O	X	X
E2	V	V	V	O	O	X	O	X	X	
E3	O	V	V	V	V	X	O	X		
E4	O	V	A	X	X	O	X			
E5	V	X	X	A	A	X				
E6	A	V	A	X	X					
E7	A	O	A	X						
E8	X	A	X							
E9	V	X								
E10	X									

E1-Government funding, E2-Government policies, E3-Process design capability, E4-Supply chain talent, E5-International rules & regulations, E6-Social values & ethics, E7- Competition, E8-Infrastructure quality & connectivity, E9-Environment awareness & knowledge E10- Technology

There are paired comparisons of each set and the parameters considered are represented by i and j. Four letters such as V, A, X, O are used to represent the type of relationship between any of these paired comparisons in the survey. Table 2 shows the structural self-interaction matrix of enablers considered in this study. The matrix is to be filled with:

V ifileads to j but j doesn't lead to i

A ifi doesn't lead to j and j leads to i

X ifi and j lead to each other

O ifi and j are not related each other

3.1.1 Transitivity Principle

Transitivity principle is used in ISM to check the consistency of the model developed (Farris and Sage 1975; Vivek et al. 2008; Sushil 2015a, b; Kwak et al. 2018). According to transitivity principle, if a leads to b and b leads to c then based on this logic we can argue that a leads to c. Transitivity property also helps to remove any possible gaps among the variables. The final reachability matrix for enablers shown in Table 3 is prepared by adopting the above mentioned criteria and transitivity principle.

3.1.2 Level Partitioning

The process of ranking different variables into different levels is called level partitioning. To derive the levels of variables, the first step involved is the calculation of reachability and antecedent sets from Table 2 (Warfield, 1974; Vivek et al. 2008; Sushil, 2012; Haleem et al., 2012; Purohit et al., 2016). In any iteration, if the reachability set intersection antecedent set is the reachability set itself, and then that variable will be placed in the top level of the hierarchy. The MICMAC analysis showed in Figure 1 for enablers clearly bifurcate the enablers into four quadrants depending on their driving power and dependency. The final output of level partitioning is shown in Table 4, and the conceptual framework of enablers of sustainability oriented frugal innovation in supply chain is shown in Figure 2. The transitivity links based on expert opinion is shown in Table 5.

Table 3: Final binary matrix-enablers

	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	Driving power
E1	1	1	0	1	1	1	1	0	1	-	8
E2	1	1	1	1	1	1	1	1	-	1	10
E3	0	1	1	1	1	1	1	-	1	0	8
E4	0	1	0	1	1	0	-	0	0	0	4
E5	1	1	1	0	0	-	0	0	0	0	4
E6	0	1	0	1	-	1	1	0	0	0	5
E7	0	0	0	-	1	1	1	0	0	0	4
E8	1	1	-	1	1	1	1	0	0	0	7
E9	1	-	1	0	0	1	0	0	0	0	4
E10	-	1	1	1	1	1	0	0	0	0	6
Dependence	6	9	6	8	8	9	7	2	3	2	

E1-Government funding, E2-Government policies, E3-Process design capability, E4-Supply chain talent, E5-International rules & regulations, E6-Social values & ethics, E7- Competition, E8-Infrastructure quality & connectivity, E9-Environment awareness & knowledge E10- Technology

Table 4: Level matrix of enablers

Variable	Level
E5,E9	Level 1
E4,E6,E7	Level 2
E8,E10	Level 3
E1,E2,E3	Level 4

E1-Government funding, E2-Government policies, E3-Process design capability, E4-Supply chain talent, E5-International rules & regulations, E6-Social values & ethics, E7- Competition, E8-Infrastructure quality & connectivity, E9-Environment awareness & knowledge E10- Technology

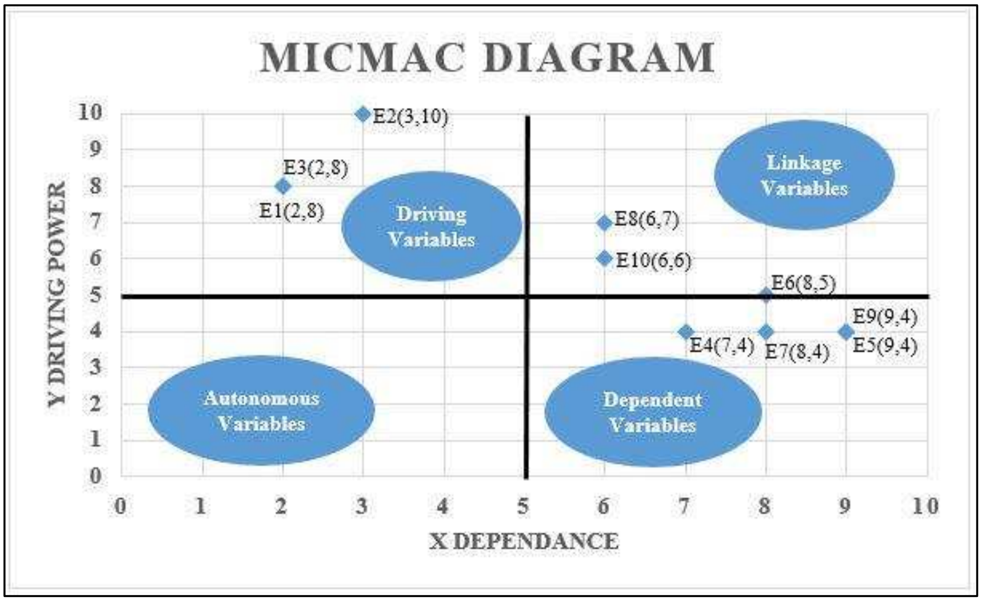


Figure 1: MICMAC analysis of enablers

E1-Government funding, E2-Government policies, E3-Process design capability, E4-Supply chain talent, E5-International rules & regulations, E6-Social values & ethics, E7- Competition, E8-Infrastructure quality & connectivity, E9-Environment awareness & knowledge E10- Technology

Table 5: Transitive links from experts for enablers

Interpretive Matrix										
	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**
E1		Funding for R & D					Peaceful and secure atmosphere for business			Minimum financial burden
E2	Policies for fund allocation		Custom made inclusive policies	Quality of Education		Inclusive growth and equality	Open market and policies	Quality and economic infra-structure		Joint ventures and collaboration
E3		Talented policy makers		Process driven systems				Better Planning and coordination		
E4						No Blind believes and Taboos			Better awareness and efficient usage	
E5									Better International Exposure	
E6				Behavioral stability	Mutual respect and equal opportunity		Social Justice and equality		Ethical behavior and natural resource conservation	
E7					Globalization and open market	Better living standards				
E8				Better investment and Better earnings		Mixing up of various cultures through better connectivity			Minimum pollution	Robust logistics and better responsiveness

E9					Better aware-ness on inter-national complia nces					
E10					Clear and Transpa rent Policies	Better Exposure	Better Opportun ities	Improved Funding	Efficient and scientific utilization of natural resources	

E1-Government funding, E2-Government policies, E3-Process design capability, E4-Supply chain talent, E5-International rules & regulations, E6-Social values & ethics, E7- Competition, E8-Infrastructure quality & connectivity, E9-Environment awareness & knowledge E10- Technology

Figure 2: TISM model of enablers

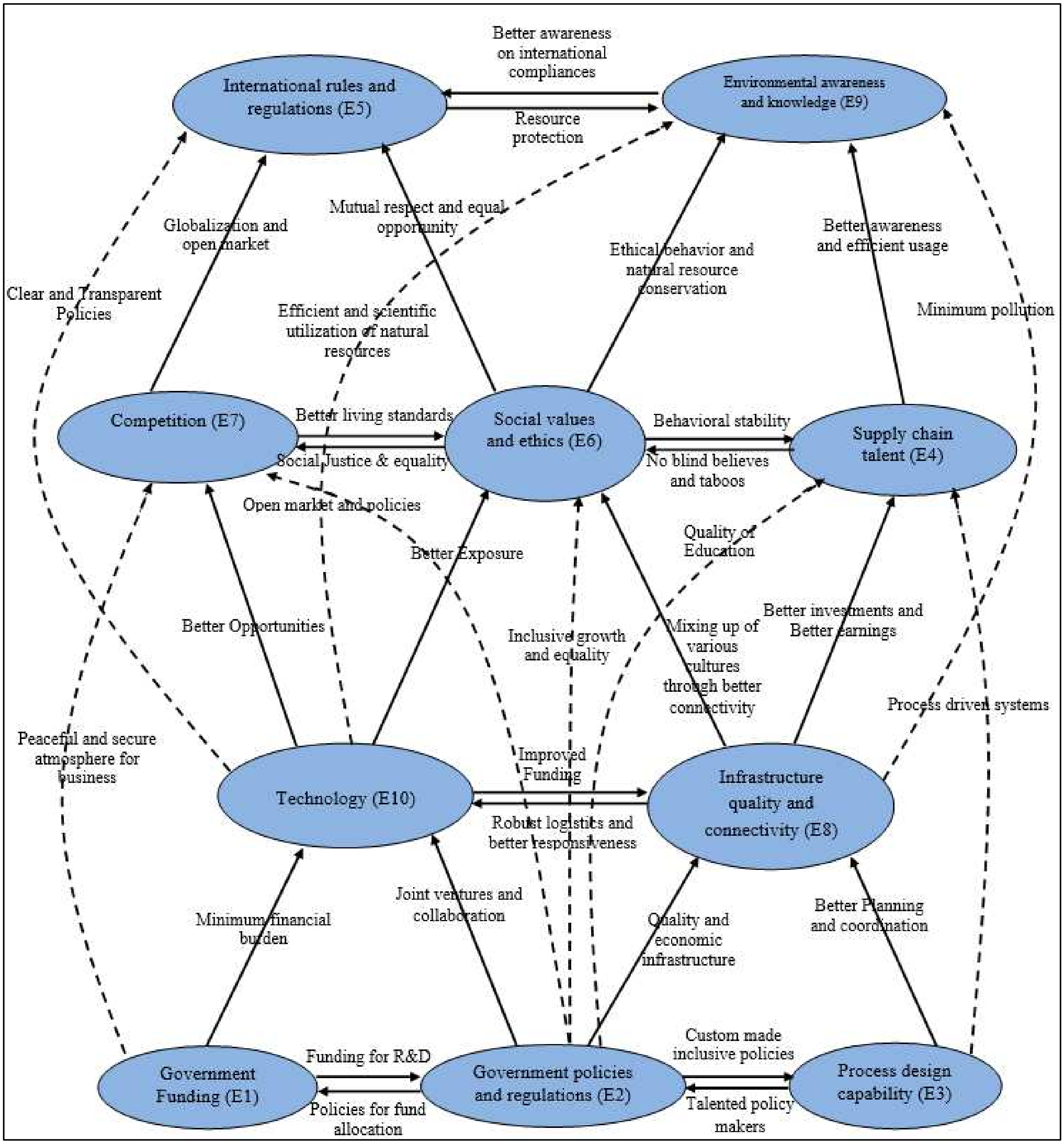


Figure 2 is the final output of the analysis. It clearly depicts the levels and the interactions of the enablers selected. The model is categorizing the enablers into four different levels depending upon the dependability and driving power of enablers. Dotted lines in the model are representing the transitive links between the enablers. Bold lines are representing the linkages between the enablers with a description of the linkage based on the expert opinion. Detailed analysis of the model is explained in the discussion section.

3.2 Phase 2: Quantitative Survey Research

We used the survey method to test our theoretical framework obtained via interpretive logic (see Figure 2). A survey based instrument was developed by identifying appropriate measures via extensive literature review. Some modifications were made to the existing scale to make those suitable in context to automotive SMEs. All the constructs were operationalized as reflective constructs (see Appendix B).

3.2.1 Data Collection

The survey was administered to managers in Indian automotive SMEs which have embraced sustainability in supply chain. A sample was drawn from the Automotive Component Manufacturers Association of India (ACMA) database. We requested a marketing manager at ACMA to randomly distribute 300 questionnaires to the supply chain head/logistics head/purchasing head/operations head of automotive components manufacturing units. Two waves of invitations were sent in the month of December, 2017. The survey responses were carefully examined and some cases were eliminated based on the following criteria. We followed the key informant approach and screened the responses and eliminated those from respondents whose titles were not directly related to supply chain functions. The resulting respondents sample held positions such as President, Vice President, Senior Director, Head, Senior Manager and Manager. Next, we eliminated cases that contained missing information. The resulting dataset has 86 responses which represent 28.67% (see Appendix C). We tested for nonresponse bias following Armstrong and Overton (1977) suggestion. We compared the responses for every measurement item between early respondents (first 25%) to late respondents (last 25%). We found no statistically significant differences between early respondents and late respondents. Hence, we can argue that the nonresponse bias is not a serious issue in our case.

3.2.2 Measurement Validation

In our study we have used WarpPLS 5.0, which relies on Partial Least Squares (PLS) method to estimate hypothesized model (see Figure 2). Peng and Lai (2012) argues that PLS is a prediction oriented and thus allows researcher to assess the predictive validity of exogenous variables. The Figure 2, obtained via interpretive logic- are not examined in the literature; therefore, there is no theoretical foundation anticipating the relationships among enablers in this study, which makes PLS an appropriate method for data analysis in this study (Thirupathi and Vinodh, 2016).

To assess the measurement model, we examined the constructs individual-item reliabilities, the convergent validity of the measures associated with each construct, and their construct validity. Table 6 shows the range of factors loadings, the composite reliability (SCR) and the average variance extracted (AVE) of the constructs. All item loadings on their respective constructs were greater than 0.5 and significant at the 0.001 level, indicating convergent validity at the indicator level (Bagozzi and Yi, 1988). The composite reliability (SCR) value of all constructs were greater than 0.7, indicating acceptable reliability (Fornell and Larcker, 1981). All AVE values are greater than 0.5, suggesting convergent validity at construct level (Fornell and Larcker, 1981; Peng and Lai, 2012).

Table 6: Loadings of the indicator variables, SCR and AVE

Items	Factor loadings	Variance	Error	SCR	AVE
GF1	0.71	0.50	0.50	0.75	0.51
GF2	0.87	0.76	0.24		
GF3	0.52	0.27	0.73		
GPR2	0.97	0.95	0.05	0.84	0.64
GPR3	0.79	0.62	0.38		
GPR4	0.61	0.37	0.63		
PDC2	0.86	0.73	0.27	0.90	0.82
PDC3	0.98	0.96	0.04		
PDC4	0.99	0.99	0.01		
PDC5	0.77	0.60	0.40		
IQC1	0.91	0.84	0.16	0.91	0.78
IQC2	0.91	0.83	0.17		
IQC3	0.81	0.66	0.34		
TA1	0.57	0.33	0.67	0.78	0.63
TA2	0.70	0.49	0.51		
TA3	0.83	0.70	0.30		
TA4	0.76	0.58	0.42		

TA5	1.00	0.99	0.01		
TA6	0.58	0.34	0.66		
TA7	1.00	0.99	0.01		
CO1	0.57	0.32	0.68	0.74	0.49
CO2	0.84	0.71	0.29		
CO3	0.66	0.43	0.57		
EAK1	0.72	0.51	0.49	0.85	0.73
EAK2	0.86	0.75	0.25		
EAK3	0.88	0.78	0.22		
EAK4	0.90	0.80	0.20		
EAK5	0.93	0.87	0.13		
EAK6	0.81	0.66	0.34		
IRR1	0.53	0.28	0.72	0.71	0.53
IRR2	0.65	0.42	0.58		
IRR3	0.70	0.49	0.51		
IRR4	0.70	0.49	0.51		
IRR5	0.97	0.94	0.06		
SVE1	0.87	0.75	0.25	0.89	0.80
SVE2	0.82	0.67	0.33		
SVE3	1.00	0.99	0.01		
SVE4	0.90	0.80	0.20		
SCT1	0.82	0.68	0.32	0.83	0.69
SCT2	0.76	0.57	0.43		
SCT3	0.89	0.80	0.20		
SCT4	0.83	0.70	0.30		

Notes: GF-Government funding; GPR- Government policies & regulations; PDC- Process design capability; IQC- Infrastructure quality & connectivity; TA-Technology; CO-competition; EAK-environmental awareness & knowledge; IRR- International rules & regulations; SVE-social values & ethics; SCT-supply chain talent

Chin (1998) argues that if the square root of the AVE is greater than all of the inter-construct correlations, it is evidence of sufficient discriminant validity. The results in the Table 7 suggest that our measurement model demonstrates sufficient discriminant validity.

Table 7: Correlation among major constructs

	GF	GPR	PDC	IQC	TA	CO	EAK	IRR	SVE	SCT
GF	**0.71**									
GPR	-0.33	**0.80**								
PDC	0.40	0.05	**0.91**							
IQC	0.55	-0.09	0.28	**0.88**						
TA	0.55	-0.12	0.36	0.58	**0.79**					
CO	0.03	0.20	0.10	-0.04	0.18	**0.70**				
EAK	-0.32	0.25	-0.16	-0.22	-0.30	-0.02	**0.85**			
IRR	0.68	-0.13	0.58	0.49	0.55	0.06	-0.22	**0.73**		
SVE	0.47	-0.29	0.32	0.35	0.37	-0.04	-0.32	0.42	**0.89**	
SCT	0.05	0.03	0.04	-0.13	-0.01	0.05	-0.16	0.04	0.06	**0.83**

Notes: GF-Government funding; GPR- Government policies & regulations; PDC- Process design capability; IQC- Infrastructure quality & connectivity; TA-Technology; CO-competition; EAK-environmental awareness & knowledge; IRR- International rules & regulations; SVE-social values & ethics; SCT-supply chain talent

3.2.3 Common Method Bias

To test our theoretical framework (see Figure 2), we have gathered data using single informant instrument. Hence, there is the potential for common method bias (CMB). The survey has been designed by including different scale formats and anchors, to dampen the potential for CMB. In addition, we have conducted some additional statistical tests for CMB. First, we have conducted Harman's one factor test to examine that the results are not biased because of single respondent (Podsakoff and Organ, 1986). This requires loading all the measures into an exploratory factor analysis, and analyzing the unrotated factor solution with the assumption that presence of CMB is indicated by the emergence of either a single factor or general factor accounting for the majority of covariance among measures (Podsakoff et al. 2003, p.98). In this case we have fixed the number of factors equal to one, prior to obtaining an unrotated factor solution. A single factor was obtained which explains 36.54 (approx.) percent of variance. Second, we tested for CMB using correlation marker technique (Lindell and Whitney, 2001). We used unrelated variable to partial out the correlations caused by CMB. In addition, we calculated the significances of the correlations using the equations provided by Lindell and Whitney (2001). There were minimal differences between adjusted and anadjusted correlations. Furthermore, the significance of the correlations did not change. Hence, based on these results, we argue that the potential effects of common method variance to be non-substantial.

Finally, following Kock's suggestions (2015) we performed nonlinear bivariate causality direction ratio (NLBCDR). The NLBCDR refers to *"... an interesting property of nonlinear* algorithms ... that bivariate nonlinear coefficients of association vary depending upon hypothesized direction of the causality. That, is they tend to be stronger in one direction than the other, which means that the residual (or error) is greater when the hypothesized direction of causality is one way or the other. Hence, the NLBCDR index is a measure of the extent to which bivariate nonlinear coefficients of association provide support for the hypothesized directions of *the causal links in the model."* (Kock, 2015, pp. 52-53). The desired acceptable value is greater than 0.7. In our model the NLBCDR=0.917, which is greater than the cut off value. Hence, we can argue that causality is not a serious concern in our study. We have further tested the model fit and quality indices (see, Table 8).

Table 8: Model fit and quality indices

Model fit and quality indices	Value from analysis	Acceptable if	Reference
APC	0.358, p=0.001	p<0.05	Rosenthal and Rosnow (1991)
ARS	0.399, p<0.001	p<0.05	
AVIF	1.454, p<0.001	p<0.05	Kock (2015)
Tenenhaus GoF	0.540	Large if ≥ 0.36	Tenenhaus et al. (2005)

3.2.4 Model Estimation and Analysis

Since, PLS does not assume normal distribution, traditional parametric-based techniques for significance tests are inappropriate. The PLS uses a bootstrapping procedure to estimate standard errors and the significance of parameter estimates (Chin, 1998; Peng and Lai, 2012; Moshtari, 2016; Akter et al. 2017). We have reported the PLS path coefficients and p-values for the model in Table 9.

Table 9: Structural Estimates

Effect of	Effect on	β	p-value	Results
GPR	GF	0.67	***	supported
GPR	PDC	0.76	***	supported
GPR	TA	0.48	***	supported
GPR	IQC	0.03	0.39	not supported
GF	TA	0.44	***	supported
PDC	IQC	0.14	*	supported
TA	IQC	0.55	***	supported
TA	CO	0.66	***	supported
TA	SVE	-0.32	***	not supported
IQC	SVE	0.09	0.19	not supported
IQC	SCT	-0.23	***	not supported
SVE	CO	0.16	*	supported
SVE	SCT	0.44	***	supported
CO	IRR	0.14	*	supported
SVE	IRR	0.76	***	supported
SVE	EAK	0.25	***	supported
SCT	EAK	0.12	0.12	not supported
IRR	EAK	-0.21	**	not supported

Notes: GF-Government funding; GPR- Government policies & regulations; PDC- Process design capability; IQC- Infrastructure quality & connectivity; TA-Technology; CO-competition; EAK-environmental awareness & knowledge; IRR- International rules & regulations; SVE-social values & ethics; SCT-supply chain talent

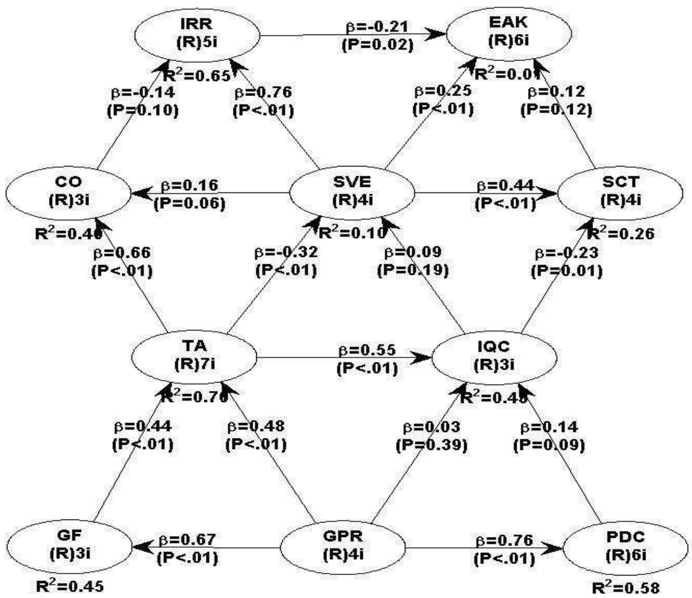


Figure 3: Final causal model

We have further examined the explanatory power of the research model. For this we have examined the explained variance (R^2) of the endogenous constructs. The R^2 for IRR=0.65, EAK=0.01, CO=0.41, SVE=0.1, SCT=0.26, TA=0.7, IQC=0.45, GF=0.45 and PDC=0.58, respectively. To evaluate the effect size of each predictor construct, we have used Cohen f^2 formula. f^2 is equal to the increase in R^2, w.r.t to the proportion of variance that remains unexplained in the endogenous latent variable. Based on Cohen (1988) works, f^2 values of 0.35, 0.15 and 0.022 are considered large, medium and small. Consequently the effect sizes of the predictor variables are shown in Table 10.

Table 10: f-squared coefficients

	GF	GPR	PDC	IQC	TA	CO	EAK	IRR	SVE	SCT
GF										
GPR										
PDC		0.58								
IQC		0.02	0.06		0.36					
TA	0.33	0.37								
CO					0.49				0.08	
EAK								0.08	0.10	0.03
IRR						0.05			0.61	
SVE				0.02	0.11					
SCT				0.06					0.20	

To examine the model's capability to predict, Stone-Geisser's Q^2 for endogenous constructs are greater than 0.0, indicating acceptable predictive relevance (Peng and Lai, 2012).

Table 11: Q-squared coefficients

GF	GPR	PDC	IQC	TA	CO	EAK	IRR	SVE	SCT
0.46		0.57	0.45	0.69	0.57	0.2	0.66	0.12	0.26

4. Discussion of Results and Implications for Theory and Practice

Our results strengthen and refine previous studies on supply chain sustainability and frugal innovations, answering respective research calls (Prahlad, 2012; Sharma and Iyer, 2012; Levanen et al. 2015; Bendul et al. 2017; Rosca et al. 2017). Our study contributes to building and refining theories of sustainability and frugal innovations and offers empirically grounded normative recommendations to practitioners. The results demonstrate that government funding (E1), government policies and regulations (E2) and process design capability (E3) are found to be the most powerful driving factors of sustainability oriented frugal innovations in supply chain. International rules and regulations (E5) and Environmental awareness and knowledge (E9) are occupied at the top of the framework because of their higher dependency. Thereby our study is the first attempt to offer a theoretical framework that establishes the connection between supply chain sustainability and frugal innovations in emerging economies which has been noted but not explored in-depth in prior research (Bendul et al. 2017). Our findings support previous arguments that: (i) the frugal innovations and sustainability concepts can coexist and can be mutually benefited as they try to be more energy- or material- efficient; (ii) technologies that are more simple and popular, they are pro-poor and consider society as a whole should be considered; and (iii) researchers should emphasize on the frugal innovation and sustainability concepts for the benefit of the society and environment, especially for the emerging markets and SMEs (see, Immelt et al. 2009; Rosenberg, 2013; Bendul et al. 2017; Rosca et al. 2017).

The enablers and interlinks of sustainability oriented frugal innovations in supply chain proposed by this study will help supply chain professionals and strategy policy makers to focus on critical areas that need major focus. TISM has been used in this study, which is an interactive and participative approach based on systems theory to identify the hierarchy of enablers and their transitive links among the enablers identified. Further, we have tested our framework empirically to validate our TISM framework. The empirically tested framework will help supply chain managers to plan for the actions that are to be taken to attain the desired level in the hierarchy by analyzing all interlinks amongst the enablers. This will direct the policy makers into taking the advantage of the new supply chain business models into its next global level. The results show that the process design capability will be a real competitive advantage for the firm to go for technology advancements, which is again crucial for promoting frugal innovations. From the MICMAC diagram (see Figure 1), it is clear that the enablers used in our study are relevant as we can see that there is no autonomous variables. From Figure 1, we can also argue that the infrastructure quality & connectivity, international rules & regulations, and technology are linkage variables. These linkage variables are characterized by their strong dependency and driving power and will become very sensitive variables. That means any small change in the system or other variables will affect these linkage variables. To conclude with, this study has its own uniqueness in presenting and discussing enablers based on scientific management theories and expert opinion, and in clearly depicting the level and interlinks amongst them; both play a crucial role in imparting sustainability oriented frugal innovations in supply chains. Therefore our study extends the literature on frugality (Rao, 2013), sustainability (Bell and Morse, 2013) and supply chain innovations (Isaksson et al., 2010; Lee et al., 2011; Bendul et al. 2017) based on a combination of well-established organizational theories.

Moreover, our PLS SEM results suggest that the government funding, process design capability, technology, competition, international rules and regulation and infrastructure quality & connectivity have strong predictive relevance in comparison to social values & ethics, environmental awareness and knowledge and supply chain talent. The PLS SEM results further corroborate MICMAC analysis.

4.1 Theoretical Contributions

The frugal innovation for sustainability is an emerging research area tackling sustainability issues related to frugal innovation, which is critical to the SMEs in the emerging countries. While previous studies have limited knowledge about frugal innovation for sustainability practices, this study is one of the first attempts to fill the research gap by theoretically conceptualizing and empirically validating a frugal innovation for supply chain sustainability in SMEs model and its measurement based on integration of IT and RBV. Our interest in investigating the relationship between sustainability and frugal innovations in supply chains was triggered by two aspects. Firstly, institutional barriers and constraints in emerging economies require new supply chain models where economic, social and ecological aspects are integrated (Bendul et al. 2017). Secondly, the sustainable supply chain literature has focused on environmental and economic aspects and neglected social issues, while base of the pyramid (BOP) studies have neglected environmental considerations (Gold et al. 2013). Hence, our study makes two important contributions to the operations management literature. First, by proposing a theoretical model for frugal innovation for supply chain sustainability in SMEs is an attempt to extend the previous research attempts by scholars from strategy and operations management field (see Bhatti and Ventresca, 2013; Subramanian and Gunasekaran, 2015). Second, by using multi-methods research design approach we have attempted to answer calls for multi-methods research design to improve the reliability and validity of the study (Boyer and Swink, 2008; Cameron and Molina-Azorin, 2011; Boon-itt and Wong, 2016). Hence, we can argue that our study is one of those first attempts to integrate graph theoretical approach like ISM/TISM with SEM to provide robust solutions to emerging research problems which are often complex. Thirupathi and Vinodh (2016) have used integrated approach (ISM-SEM) to build the model to examine sustainable manufacturing practices. Building on Thirupathi and Vinod (2016), integrated approach (ISM-SEM), we have used (TISM-SEM) approach following Sushil (2012, 2017) criticisms of ISM approach.

4.2 Managerial Implications

Our study will assist managers in understanding the critical constructs of sustainable frugal innovations in supply chain and their interrelationships. Therefore, they could shift their attention to those enablers that are critical (according to our proposed framework). Managers should also consider that a clear well defined framework with strong theory base for developing nations is difficult and such studies are still scant (Bhatti, 2012). By attending to our proposed framework, SME managers in emerging economies could better understand how to improve their organizations' branding and go global by acting locally (Subramanian and Gunasekaran, 2015; Kalsaas, 2013). The dependability and driving power of enablers derived from our proposed framework can help managers prioritize the actions at each stage of their policy execution period. This approach is the best fit for SMEs in developing nations as: (i) resource and cost constraints can be overcome through frugal approach; (ii) frugality and sustainability philosophies have a natural fit; and (iii) sustainability thinking will help them to manage economic, environmental and social issues effectively to improve brand value and to go global.

4.3 Limitations and Further Research Directions

Although, we have used mixed-methods research design to address research gaps, the study has several limitations which can be used for further research. First, we have used secondary data collected via CSR and annual reports may be vetted by organizations to put themselves in the best possible light, thus overstating the performance results of frugal innovation activities in supply chain. Hence, it is advised to consider multiple sources of secondary data published by reputable agencies to reduce the potential bias induced by the corporate reports. Second, the sample frame in the interview and survey phases of the study was on automotive components manufacturers in India. Although, sample frame provides a solid empirical ground for understanding frugal innovation in supply chain for sustainability, future studies may consider other industries to improve the generalizability of findings. Third, this study focuses on generating theoretical model for frugal innovation for supply chain sustainability in SMEs and next developing the measurement of frugal innovation for supply chain sustainability. While the prior research have focused on frugal innovation, mostly anecdotal. Hence, our study can be expanded further by considering few constructs grounded in relevant theories like stakeholders resource based view theory or paradox theory and understand the implications of the frugal innovation on organizational performance.

Future, studies may consider employing longitudinal studies to investigate the costs and benefit associated with frugal innovation practices over time when firms are exposed to different conditions and regulatory regulations.

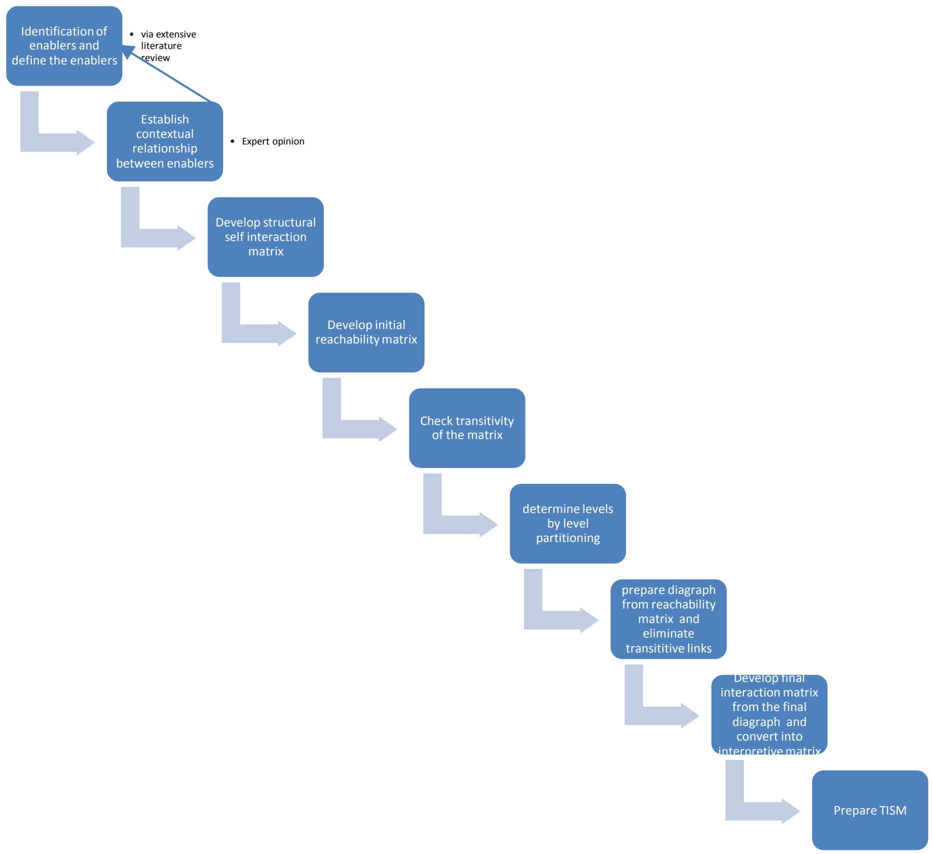
5. Conclusion

This study investigated the relationship between sustainability and frugal innovation in emerging economies. It was based on the paucity of the literature in providing (i) particular models where economic, social and ecological aspects are considered, and (ii) the discrepancy of the literature on sustainability when social issues when base of the pyramid (BOP) studies have neglected environmental considerations. To address these gaps, we drew on IT and RBV to generate a framework using TISM. Our study highlights the importance of government funding, government policies & regulations and process design capability as first order constructs and international rules & regulations and environmental awareness & knowledge as higher order constructs. Furthermore, our paper highlights the mediating role of technology, infrastructure quality & connectivity, competition, social value & ethics and supply chain talent. From a managerial perspective, our study can be of assistance to those managers who would like to trade-off between particular factors of sustainable frugal innovations in supply chain and their interrelationships. Moreover, we have validated these findings using empirical data. Thus our mixed-methods research design is an attempt to answer the pressing calls of the scholars (Boyer and Swink, 2008). We hope that our study will provide food-for-thought to those interested in exploring in depth frugal innovation in sustainable supply chains.

Acknowledgements

We thanks the anonymous reviewers and the co-editors of the Production, Planning and Control for their helpful comments.

Appendix A: Flow Diagram for Implementation of TISM



Source: Sushil (2012)

Appendix B: Scales and items

Scale	Items
Government funding (GF)	Government support procurement of scare raw materials for the SMEs (GF1)
	Government provides financial assistance to SMEs for procurement of raw materials and equipment (GF2)
	Government provides training to the workers or managers employed in SMEs (GF3)
Government policies & regulations (GPR)	Regional pollution control board is pressurizing the firm to adopt green practices (GPR1)
	Government regulations provide clear guidelines in controlling pollution level (GPR2)
	The customers are sensitive towards environmental friendly manufacturing practices (GPR3)

	Green practices decrease incidences of penalty fee charged by pollution control board (GPR4)
Process design capability (PDC)	Environmental criteria are considered while selecting suppliers (PDC1)
	Our firm considers environment collaboration with suppliers (PDC2)
	Our firm considers environmental collaboration with customers (PDC3)
	Our firm has technological integration with suppliers (PDC4)
	Our firm have reverse logistics in place to manage the product returns (PDC5)
	Our firm conducts environmental audit for suppliers at regular interval (PDC6)
Infrastructure quality & connectivity (IQC)	The logistics support in terms of seamless transportation of physical materials is good (IQC1)
	Our firm has invested in technological capability to facilitate seamless flow of information (IQC2)
	Adequate information systems linkages exist with suppliers and customers (IQC3)
Technology Adoption (TA)	Our firm is focusing on green design of products (TA1)
	The green design reduces wastage (TA2)
	Real time information is available any point of time by using Information technology infrastructure SAP/ERP (TA3)
	Our firm focuses on using alternate source of energy (TA4)
	Our firm has optimized process to reduce wastage (TA5)
	Our firm is using eco-friendly materials for packaging (TA6)
	Reduction of emission of Green House Gases in the environment by use of clean technology (TA7)
Competition (CO)	Our competitors who have embraced frugal innovation for promoting sustainability have greatly benefitted (CO1)
	The frugal innovation for promoting sustainability are favorably perceived by others within the same industry (CO2)
	The frugal innovation for promoting sustainability are favorably perceived by the stakeholders (CO3)
	Frugal innovation reduce solid waste generation (EAK1)

Environmental awareness & knowledge (EAK)	Effluent meets CPCB norms by converting into green operations (EAK2)
	Frugal innovation reduce environmental accidents and health hazards (EAK3)
	Frugal innovation decrease of cost of raw materials (EAK4)
	Frugal innovation reduce the inventory levels (EAK5)
	Frugal innovation reduce cost for energy consumption (EAK6)
International rules & regulations (IRR)	Our firm use recycled raw materials which comply with international rules and regulations (IRR1)
	Our firm monitor the carbon emission as per the international rules and regulations (IRR2)
	Our firm recycle waste water as per international rules and regulations (IRR3)
	Our firm dispose solid wastes as per international rules and regulations (IRR4)
	Our firm while recruiting workers follow the international rules and regulations (IRR5)
Social values and ethics (SVE)	Our firm does not discriminate among workers on the basis of gender (SVE1)
	Our firm pays wages to the workers as per government rules and regulation (SVE2)
	Our firm provides education to employees kids (SVE3)
	Our firm provides free or subsidized medical facilities to employees (SVE4)
Supply chain talent (SCT)	Our supply chain managers possess supply chain related qualification (SCT1)
	Our supply chain managers possess right experience (SCT2)
	Our supply chain managers can effectively communicate with their team members (SCT3)
	Our supply chain managers can predict the business uncertainties (SCT4)

Appendix C: Profile of the Respondents

Designation	Number	Percentage
President	12	13.95
Vice President	18	20.93
Senior Director	13	15.12
Head	15	17.44
Senior Manager	16	18.60
Manager	12	13.95

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