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Sustainable supply chain management: framework and further research directions

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ABSTRACT

This paper argues for the use of Total Interpretive Structural Modeling (TISM) in sustainable supply chain management (SSCM). The literature has identified antecedents and drivers for the adoption of SSCM. However, there is relatively little research on methodological approaches and techniques that take into account the dynamic nature of SSCM and bridge the existing quantitative/qualitative divide. To address this gap, this paper firstly systematically reviews the literature on SSCM drivers; secondly, it argues for the use of alternative methods research to address questions related to SSCM drivers; and thirdly, it proposes and illustrates the use of TISM and Cross Impact Matrix-multiplication applied to classification (MICMAC) analysis to test a framework that extrapolates SSCM drivers and their relationships. The framework depicts how drivers are distributed in various levels and how a particular driver influences the other through transitive links. The paper concludes with limitations and further research directions.

1. Introduction

In recent times, sustainable supply chain management (SSCM) has become a topic of interest for academics and practitioners (Carter and Rogers, 2008; Seuring and Müller, 2008; Pagell and Wu, 2009; Carter and Easton, 2011; Ahi and Searcy, 2013; Pagell and Shevchenko, 2014; Marshall et al., 2015; Li et al., 2015). According to Walmart, over 90% of its total emissions related to its operations are from its supply chain (Birchall, 2010). The interesting fact is that more than 20% of global greenhouse gases emissions are made by about 2500 largest global companies, and their supply chains are responsible for a major proportion of emissions resulting from corporate operations (Carbon Disclosure Project, 2011). Because of globalization, distribution channels of goods and services have become very complex (Reuter et al., 2010), and subsequently the socio-economic conditions of the respective regions are a major success factor of supply chain networks (Beske et al., 2008). This has led to competition between corporates based on sustainability-oriented innovations (Nidumolu et al., 2009; Hansen et al., 2009). Literature has also looked into the importance of safety, diversity, equity, and other social and economic issues within the supply chain (e.g. Maloni and Brown, 2006; Chin and Tat, 2015).

Though there is a rich body of literature on drivers of SSCM (e.g. Walker and Jones, 2012; Ahi and Searcy, 2013; Diabat et al., 2014), the majority of the scholars have been engaging with empirical methods, either quantitative or qualitative, to create theoretical frameworks that entail drivers (Binder and Edwards, 2010; Soltani et al., 2014). In recent years some scholars have argued that in its majority, literature on SSCM has been following a dichotomist view

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on creating frameworks for SSCM drivers, following either deductive empirical research (e.g. Markman and Krause, 2014), or case study approaches (e.g. Meredith, 1998; Pagell and Wu, 2009; Ketokivi and Choi, 2014). Wells (1993) argues that over-reliance on quantitative methods hampers the theoretical framework development process, since qualitative methods may do in-depth analysis of a problem through an inductive process, while theory generated by using qualitative methods remains untested (Hyde, 2000). Deductive approaches are highly reliable, but may fail to give new insights (Markman and Krause, 2014). Cases that build theory are often regarded as "most interesting" researches (Bartunek et al., 2006). There are a considerable amount of case study researches in SSCM area, but there is no clarity or criteria mentioned for the selection of case, data collection methodology or number of cases under study (Giunipero et al., 2006). Hence, in many situations, case studies may not become an effective tool for developing a strategic framework for a philosophical idea. The use of case studies for theory building has been criticized on the grounds of "ambiguity of inferred hypotheses" and the "selective bias" (Bitektine, 2008: 161; Barratt et al., 2011), especially by those scholars who are not familiar with qualitative methods (Bitektine, 2008; Roth, 2007).

This paper aims to bridge this debate by arguing for the use of Total Interpretive Structural Modeling (TISM). We are driven by the endorsement of scholars such as Barratt et al. (2011) and Taylor and Taylor (2009) to (i) utilize alternative research methods and frameworks to explain OM and SCM related phenomena; and (ii) to build robust approaches and techniques that consider the dynamic environment of SCM (and in our case SSCM) instead of following either deductive or inductive approaches. We draw on Systems Theory and use TISM to develop and test a framework that extrapolates SSCM drivers and their relationships, based on a systematic literature review of SSCM drivers. Sushil (2012) argues that systems theory and systems engineering based methods may provide a helping hand to organizational researchers on this front. Identification of structure within a system is of great value in dealing effectively with the system and better decision-making. Structural models may include interaction matrices and graphs; delta charts; signal flow graphs, etc., which lack an interpretation of the embedded object or representation system. However the TISM based approach offers flexibility to enhance interpretive logic of systems engineering tools not only in delineating a hierarchical structure of the intended organizational theory, but also to interpret the links in order to explain the causality of the conceptual model by using the strengths of the paired-comparison methodology.

According to Nasim (2011) and Sushil (2012), Interpretive Structural Modeling fails to explain the causal relationships or transitive links between the constructs of the model. TISM is considered to be an extension of ISM, which helps to overcome these limitations. But even though there is a growing attention on TISM methodology, there are limited studies that used TISM as a methodology to develop theoretical frameworks (Goyal and Grover, 2012; Mangla et al., 2014; Prasad and Suri, 2011; Singh and Sushil, 2013; Srivastava and Sushil, 2014; Yadav and Sushil, 2014) and Dubey et al. (2015a,b) who suggest its use for theory building in sustainable manufacturing.

Therefore, in this paper we: (i) undertake an extensive literature review and identify key drivers of SSCM practices; and (ii) use TISM and MICMAC analysis to understand the relationship among drivers of SSCM practices and develop a theoretical SSCM drivers' framework.

The rest of the paper is organized as follows. In the following section we outline our systematic literature review. In the third section we outline our research theoretical framework and research methodology. In Section 4, we present our SSCM theoretical framework as the outcome of the MICMAC analysis. We relate this to literature in the Discussion, Section 5, and in Section 6, we conclude our research and provide further research directions.

2. Literature review

2.1. Sustainable supply chain and drivers

Sustainable supply chain concerns the "management of material, in-formation and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements" (Seuring and Müller, 2008: p. 1700). Reviews of the literature on the definitions of SSCM (e.g. Carter and Easton, 2011; Ahi and Searcy, 2013; Pagell and Shevchenko, 2014) suggest that SSCM is the voluntary integration of social, economic, and environmental considerations with the key inter organizational business systems to create a coordinated supply chain to effectively manage the material, information and capital flows associated with the procurement, production and distribution of products or services to fulfill short term and long term profitability, stakeholder requirements, competitiveness and resilience of the organization. Therefore, SSCM can be understood as SCM focusing on maintaining environmental, economic, and social stability for long-term sustainable growth (Linton et al., 2007; Ahi and Searcy, 2013; Leppelt et al., 2013).

A literature review was conducted for the purposes of this research following the tenets of systematic literature review (SLR) explained by Tranfield et al. (2003) and later studies (e.g. Rowley and Slack, 2004; Burgess et al., 2006; Cousins et al., 2006; Chen et al., 2014; Gunasekaran et al., 2015). The literature review aimed to identify and classify drivers of SSCM. The papers were derived using keywords from following databases: Proquest, Science Direct, EBSCO, SCOPUS, Emerald, Springer, Inspec, and Compendex. The keywords we included were: 'sustainable supply chain', 'green supply chain', 'sustainability', 'drivers', and 'strategic framework'. Within these databases, we accessed reputable journals in the field of operations and sustainable supply chain management, as well as edited books and reports. These papers were further scanned and analyzed (Chen et al., 2010; Merali et al., 2012) to identify and interpret themes and features. This process yielded 102 articles that we have included in our research. From this literature we classified the key drivers of SSCM. Twelve themes arose, as described in the following sub-sections.

2.1.1. Green warehousing

Warehouses generate much of the packaging waste in the supply chain. The use of standard re-usable containers is a solution for this to reduce cost and eliminate waste. Maximizing storage area utilization, minimizing storage and retrieval cost, and minimizing energy usage are the important objectives that are to be taken care of at warehouses (Wu and Dunn, 1995).

Harris et al. (2011) emphasize the importance of a proper warehouse management system for sustainability performance. Wang et al. (2015) underline the importance of recycling facilities at warehouses. Other scholars (see, Rizzo, 2006; Colicchia et al., 2011; McKinnon et al., 2010) have recognized the importance of warehouse sustainability and suggest that green warehouses and issues related to the use of green energy sources and strategies as well as the adoption of energy-efficient handling technologies are important topics for future sustainability research. Therefore, we identify green warehousing as one of the main SSCM drivers.

2.1.2. Strategic supplier collaboration

Collaboration helps to commercialize and to ensure easy access to innovative technologies for the local and lower-tier suppliers in the supply chain (Vachon and Klassen, 2008; Dam and Petkova, 2014; Glover et al., 2014). Research on the role of environmental collaboration has mainly focused on its antecedents and performance implications (e.g. Zhu et al., 2013; Grekova et al., 2016). Lee (2010) illustrates the success story of inter organizational supply chain collaboration, which helped Hewlett–Packard, Electrolux, Sony and Braun companies to reduce the recycling and disposal cost by 35% by developing a common European Recycling Platform. Collaborative planning, forecasting and replenishment systems help organizations to easily overcome financial barriers as well, which lead to the successful achievement of sustainability initiatives in supply chain (Attaran and Attaran, 2007). In a later study, Chiou et al. (2011) discussed the impact of environmental collaboration of internal processes' environmental sustainability referring to benefits such as clean technologies, lower energy consumption, and material re-use. Grekova et al. (2016) suggest that environmental supplier collaboration can enhance the focal firm's performance both directly (Zhu et al., 2007; De Giovanni, 2012) and indirectly (Dyer and Singh, 1998), that is, by stimulating the firm to invest in and implement more sustainable processes that influence the firm's performance. Thus, we argue that strategic supplier collaboration is acute for the success of SSCM, and is considered as one of the drivers of SSCM.

2.1.3. Environment conservation

Researchers are unanimously in favor of the arguments to conserve the environment for sustainable development. The Intergovernmental Panel on Climate Change (2014) demands the full stoppage of fossil fuel usage by 2100, to control the world carbon footprint. Many of the articles in the literature explain the need for eco-friendly processes, technologies, products; energy efficient systems and conservation techniques (see for example, Wiese et al., 2012; Abbasi and Nilsson, 2012; Gotschol et al., 2014). According to Wu and Pagell (2011) environmental strategies adopted by organizations have a direct impact on the supply chain and competitiveness of the organization. Ji et al. (2014) explain various methods for environmental conservation which include: improving demand forecast accuracy, investment in carbon reduction technology, joint distribution, adopting cross-docking networks, improving energy efficiency, combining design for ecology and comprehensive take-back networks. Thus, we argue to consider environment conservation as an important driver of sustainable supply chain framework.

2.1.4. Continuous improvement

Audit, assessment and standardization are considered to be the key tools for continuous improvement, which help organizations to quantify the performance and to continuously strive for better sustainability performance (e.g. Bateman, 2005; Savino and Mazza, 2014; Martínez-Jurado and Moyano-Fuentes, 2014). Organizations can either adopt standard assessment practices such as ISO14000, eco-management and the European Union audit scheme, etc. (Chen, 2005; Kleindorfer et al., 2015; Curkovic and Sroufe, 2011); or can go for their own assessment systems to continuously improve their performance (Spence and Bourlakis, 2009; Foerstl et al., 2010). Audit and standardization help organizations to benchmark their practices with best in class prevailing in the world and can try to achieve the same (see, Turker and Altuntas, 2014; Grosvold et al., 2014; Ching and Moreira, 2014). Hence, we argue that continuous improvement initiatives play an important role in the successful implementation of SSCM.

2.1.5. Enabling Information Technologies

Nowadays, sustainable and ecofriendly technologies are fast approaching parity in terms of conventional solutions (Gunasekaran and Ngai, 2004; Qrunfleh and Tarafdar, 2014). Sustainable technologies are reconfigurable, recyclable and cleaner technologies that do not harm societies and nature (Liu et al., 2011; Koren et al., 1999; Liu and Liang, 2008). According to Sarkis and Weinrach (2001), waste treatment is another important area that needs attention in the sustainable development strategy. Thus, we argue that enabling technologies and information must be considered as an enabler in the strategic framework formulation of sustainable supply chain.

2.1.6. Logistics optimization

Logistics optimization can be explained as the optimization of the speed, route, load and nature of transport; use of alternate fuels instead of fossil fuels; reverse logistics; logistics collaboration etc. which will significantly contribute to the profitability margin and greenhouse gas emission control of the business organization (Neto et al., 2008; Garetti and Taisch, 2011; Boix et al., 2015). Halldorsson and Kovacs (2010) also emphasize the need to have energy efficient logistics and supply chain system for better sustainability and to reduce global carbon footprint. Dowlatshahi (2000) and Gonzalez-Torre et al. (2004), further emphasize the need to develop reverse logistics networks, to increase the utilization of resources and for the reuse and recycling of the product. In a recent study, Nikolaou et al. (2013) integrate Corporate Social Responsibility (CSR) and sustainability issues in reverse logistics systems and relate them to sustainability performance based on the Triple Bottom Line approach. Bai and Sarkis (2010) suggest that more research should be done into the incorporation of logistics optimization for understanding sustainable green supply chain research and practice. Hence, we argue to consider logistics optimization as one of the relevant drivers of SSCM.

2.1.7. Internal pressures

Internal pressures can be explained as the pressures and demands from the employees of an organization. Scholars (e.g. Hanna et al., 2000; Carter and Rogers, 2008) have highlighted the role of employee involvement and loyalty for the success of sustainable initiatives (Longoni et al., 2014). To maintain high employee morale and loyalty, labor sustainability is to be considered by ensuring proper working conditions and the health and well-being of employees (see Tapiero and Kogan, 2008; Labuschagne and Brent, 2008). Mont and Leire (2009) further argue for socially responsible purchasing for better sustainability performance. However, scholars have also suggested that despite the pressures, change management experts still do not possess the knowledge of how to achieve sustainability (Jabbour and Jabbour, 2009). Scholars also suggest that employee engagement in sustainability is a significant challenge since sustainability requires changes to practices and routines (Carter et al., 2007; Gattiker and Carter, 2010). Hence, internal resistance needs to be studied more extensively (Carter et al., 2007; Paggell and Gobeli, 2009; Gattiker and Carter, 2010), and hence 'internal pressures' is an important driver of SSCM.

2.1.8. Institutional pressures

According to DiMaggio and Powell (1983), organizational processes are institutionalized following an adaptive process that is influenced by individuals, leading to 'institutional isomorphism'. This terms is used to denote the consequence of imitation or governmental/regulatory norms (Kauppi, 2013). Institutional Theory can help us understand, hence, the adoption of practices and the intention behind their adoption or implementation. The three dimensions of Institutional Theory are coercive pressures, normative pressures and mimetic pressures (DiMaggio and Powell, 1983). Coercive isomorphism is the outcome of formal and informal external pressures (e.g. buyers, agencies, regulatory norms). Normative isomorphism is the result of professionalization, that is, "…. *the collective struggle of members of an occupation to define the working conditions and their methods to work and in future guide the future professionals through legitimacy…*" (Liang et al., 2007: p. 62). Mimetic isomorphism is the outcome of mimicking other organizational actions, especially when there is limited clarity of organizational goals, or when there is uncertainty with regards to the environment in which an organization operates, or when the organization does not have an in-depth understanding of technology (DiMaggio and Powell, 1983; Liang et al., 2007).

In OM and SCM research, Institutional Theory has been used to explain adoption (Ketokivi and Schroeder, 2004; Ketchen and Hult, 2007; Liu et al., 2010; Sarkis et al., 2011; Bhakoo and Choi, 2013; Kauppi, 2013). Zhu et al. (2007) have investigated the impact of coercive and normative pressures on the adoption of SSCM, whereas Bhakoo and Choi (2013) discuss the institutional pressures emerging while an organization strives to adopt inter-organizational systems. Dubey et al. (2015a,b) present a case study to show the importance of legislation in pushing organizations to adopt environmentally friendly practices. Since the impact of institutional pressures on SSCM is yet to be realized (Ketchen and Hult, 2007; Cai et al., 2010; Law and Gunasekaran, 2012; Kauppi, 2013), we argue that institutional pressure is a very important driving force of sustainable supply chain management.

2.1.9. Social values & ethics

The role of social values and ethics in sustainable development has received immense attention in recent years and became a major topic of debate among researchers. Strong business ethics is essential factor for the success of sustainability initiatives in an organization (Gunasekaran and Spalanzani, 2012). Scholars (e.g. Drake and Schlachter, 2008; Roberts, 2003; Mueller et al., 2009; Gloss et al., 2011) suggest that values and ethics contribute to successful collaboration, ethical sourcing and purchasing. Beamon (2005) further argues that engineering ethics play a major role in the design and development of an environmentally conscious supply chain. In a recent study, Eriksson (2015) suggest that future research should aim to understand ethics and moral responsibility in supply chains. Thus, we can see that social values and ethics is one of the drivers of SSCM.

2.1.10. Corporate strategy & commitment

A clear strategic-level policy and coordination of the strategic-level team with the tactical and operations levels of the organization is essential for the introduction and implementation of sustainable development in any organization (Law and Gunasekaran, 2012). A lack of corporate strategy and lack of management involvement will hamper organization's sustainability achievement efforts (Griffiths and Petrick, 2001; Carter and Dresner, 2001). Narasimhan and Das (2001) and Day and Lichtenstein (2006) further argue that the alignment of SSCM strategy and corporate strategy is also very important. Additionally, literature has highlighted the role of commitment, especially from top management, as a priority for supply chain partners who seek to implement sustainability practices (Liang et al., 2007; Gattiker and Carter, 2010; Foerstl et al., 2015). In recent studies (e.g. Abdulrahman et al., 2014; Jabbour and de Sousa Jabbour, 2016) the relationship between commitment and sustainable practices has been illustrated. Thus, we must consider corporate strategy and commitment as an important driver of SSCM.

2.1.11. Economic stability

Xia and Li-Ping Tang (2011) have noted that SSCM practices helps to shorten supply pipeline, build an agile supply channel, lower cost in supplier management, supply chains can react to market changes rapidly and less wastes in inventory. During economic meltdown the fashion organizations with sustainable supply chains have performed better in comparison to those who have relied on their traditional supply chains (De Brito et al., 2008). Hence we argue that economic stability is an important driver.

2.1.12. Green product design

Graedel et al. (1995) have argued that green product design is one of the major focus areas of some of the most successful organizations. For instance AT&T's has developed and applied a design for environment (DFE) evaluation methodology to its telecommunications products. Chen (2001) argued that green product development, which addresses environmental issues through product design and innovation as opposed to the traditional end-of-pipe-control approach, is receiving significant attention from customers, industries, and governments around the world. Finster et al. (2001) have noted that some organizations have discovered green design positively impacts business performance. Some of the scholars in their works have also noted that green product design has significant positive influence on sustainable business development (see Linton et al., 2007; Dangelico and Pujari, 2010; Sharma et al., 2010; Alblas et al., 2014; Zhu et al., 2013). Hence we argue that green product design is one of the important drivers of SSCM.

2.2. The need for alternative techniques in SSCM for theory building: TISM

Our literature review reveals that the majority of studies within SSCM do not build theory, but rather aim at testing particular hypotheses stemming from the literature mainly through the use of quantitative methods. Sutton and Staw (1995) have argued that simply reporting factor loadings or beta coefficients rarely establishes causality. Furthermore, there are case studies, but these aim at explaining 'how' and 'why' particular phenomena take place, without aiming at building theory from data. These frameworks do not provide a clear understanding of the links between and hierarchical relationships between the constructs. Furthermore, there are few studies that use Interpretive Structural Modeling (ISM) to build theoretical frameworks (e.g. Thakkar et al., 2008; Ali and Govindan, 2011; Mathiyazhagan et al., 2013; Luthra et al., 2015). However, if we consider Wacker's (1998) view on what constitutes a good operations management theory, these works do not adhere to the characteristics suggested by Whetten (1989), that is, uniqueness, parsimony, conservation, generalizability, fecundity, internal consistency, empirical riskiness, and abstraction. They either test existing theory or attempt to support past literature. To address these gaps, we propose the use of Total Interpretive Structural Modeling (TISM) to build theory through strategic theoretical framework development. TISM is an extension of the ISM (Warfield, 1974; Malone, 1975; Nasim, 2011; Sushil, 2012; Dubey et al., 2015a,b). TISM aims to deal with the limitations of the ISM regarding the limited explanation it offers on transitive "links and the causality of the linkage between building blocks of the ISM model" (p. 2). TISM has been used by researchers (e.g. Goyal and Grover, 2012; Mangla et al., 2014; Prasad and Suri, 2011; Singh and Sushil, 2013; Srivastava and Sushil, 2014; Yadav and Sushil, 2014). However, apart from studies (Dubey et al., 2015a,b) that have focused on building frameworks to extrapolate how human agency theory and institutional theory can contribute to sustainable manufacturing and in particular ecological modernization theory, TISM studies so far have not been used to generate theory in terms of strategic theoretical framework development in SSCM, giving us the impetus for this research. The steps of TISM are discussed in the next section.

3. Research design

3.1. Total Interpretive Structural Modeling steps

The steps involved in TISM are (Dubey and Ali, 2014):

- Systematic literature review on the topic under investigation and identification of variables;
- Approaching experts and explaining the guidelines of self-interaction matrix formulation to them to make the structural self-interaction matrix;
- Asking experts to fill the matrix by using V, A, X and O letters based on their expert knowledge in the area to define the relationship among two variables of the matrix;
- Converting the structural self-interaction matrix first to a binary matrix and then to a final reachability matrix by considering transitivity properties;
- Identifying the level of variables depending on the dependence power and driving power of the variable from the final reachability matrix;
- Make the reachability matrix directed graph (DIGRAPH) based on the levels of variables identified from;
- Converting the DIGRAPH into structural model (self-explanatory about the relation amongst the variables);
- Reviewing the structural model to validate the conceptual stability and make necessary changes in the model;
- Contextual relationships among the variables are derived through brain storming technique. The association between the two variables is checked with 'yes' or 'no' questions. So, the total number of paired comparisons required is nC_2, i.e. a total of 66 comparisons for 12 variables;

The final TISM model is built based on the expert explanation of the interpretive logic between the drivers (Dubey and Ali, 2014).

The application of the TISM technique is outlined in the subsequent sections.

3.2. Interpretive knowledge base

The first step in developing a theoretical framework by using TISM is to identify the twelve drivers of SSM as identified from our literature review in the previous sections, (Table 1). Next, we created an interpretive knowledge base to capture the opinions of the experts.

To find experts we identified practitioners who have implemented or are in the process of implementing sustainability initiatives within their supply chains. They have significant experience and are working at the tactical level of supply chain operations. The experts were consulted to verify the drivers that stemmed from the literature review in the context of Indian manufacturing. The wording of the variables was verified but we did not drop or add new variables.

3.3. Sampling design and data collection

In our study, 24 manufacturing firms were identified from various sectors including automotive, fast moving consumer goods, and chemicals. The targeted experts have twenty plus years of experience and were working in the tactic level of supply chain operations. Ten academics from reputable engineering and management institutes were also consulted for the survey of the SSCM drivers. The use of professional networking sites made our efforts much easier.

The questionnaire was emailed to a total of 34 experts out of which 28 exploitable responses were considered for the study. Thus, we achieved a response rate of 82.4%.

3.4. Interpretive logic matrix

As per TISM technique, we used the survey to establish the contextual relationships between the drivers identified earlier, and the structural self-interaction matrix (SSIM) matrix emerged (Table 2). The relationship among the variables in the survey, are denoted by V, A, X, and O. Using the symbols *i* and *j* to denote columns and rows, the relationships between nodes are shown as follows:

V: if *i* leads to *j* but *j* doesn't lead to *i*.
A: if *i* doesn't lead to *j* but *j* leads to *i*.
X: if *i* and *j* lead to each other.
O: if *i* and *j* are not related each other.

4. Data analysis and results

4.1. Structural model

The SSIM matrix (Table 2) is further converted into initial and final reachability matrices (see Tables 3 and 4). The initial reachability matrix emerged when we converted the SSIM matrix by substituting V, A, X and O by 1 and 0 as per the following rules (Singh and Kant, 2008):

- If the (*i*, *j*) relationship in SSIM Matrix is V, the corresponding binary relationship is 1 for (*i*, *j*) and is 0 for (*j*, *i*).
- If the (*i*, *j*) relationship in SSIM Matrix is A, the corresponding binary relationship is 0 for (*i*, *j*) and is 1 for (*j*, *i*).
- If the (*i*, *j*) relationship in SSIM Matrix is X, the corresponding binary relationship is 1 for both (*j*, *i*) and (*i*, *j*).
- If the (*i*, *j*) relationship in SSIM Matrix is O, the corresponding binary relationship is 0 for both (*j*, *i*) and (*i*, *j*).

We used the 'transitivity principle' to create the final reachability matrix (Farris and Sage, 1975; Sushil, 2005a,b; Dubey and Ali, 2014; Dubey et al., 2015a,b). The transitivity principle can be explained with an illustrative example: if a leads to b and b leads to c, the transitivity property implies that a leads to c. The transitivity property helps to remove the gaps among the variables if any. By adopting the above criteria, the final reachability matrix is prepared and is shown in Table 4.

4.2. MICMAC analysis

In this case, it is desirable to seek a method by which can draw up the hierarchical relationship among them and also to establish which of the myriad indicators are 'stand-alone' ones in their impacts, which ones do not hold true, and which ones generate secondary and higher order impacts. Cross Impact Matrix-multiplication applied to classification (MICMAC) can be used as the best tool to meet the purpose (Duperrin and Godet, 1975; Dubey et al., 2015a,b). After preparing the ISM model, MICMAC diagram of the variables is prepared based on their driving power and dependence. Driving power and dependence is calculated in the final reachability matrix and are shown in Table 4. According to Dubey and Ali (2014), driving power is calculated "by summing the entries of the possibilities of interactions in the rows" and the dependence "is determined by summing the entries of possibilities of interactions in the columns" (p. 137).

Table 1
Drivers of SSCM.

Drivers	References
Green warehousing	Rizzo (2006), Colicchia et al. (2011), McKinnon et al. (2010), Dubey et al. (2013), Amemba et al. (2013), Rokka and Uusitalo (2008), Appolloni et al. (2014), Coyle et al. (2014)
Strategic supplier collaboration	Dyer and Singh (1998), Zhu et al. (2007), Lee (2010), Chiou et al. (2011), De Giovanni (2012), Gimenez et al. (2012), Kang et al. (2012), Grekova et al. (2016)
Environment conservation	Wu and Pagell (2011), Wiese et al. (2012), Abbasi and Nilsson (2012), Zhu et al. (2013), Gotschol et al. (2014)
Continuous improvement	Spence and Bourlakis (2009), Foerstl et al. (2010), Grimm et al. (2011), Ching and Moreira (2014), Turker and Altuntas (2014)
Enabling information technologies	Gunasekaran and Ngai (2004), Liu et al. (2011), Koren et al. (1999), Liu and Liang (2008), Qrunfleh and Tarafdar (2014)
Logistics optimization	Neto et al. (2008), Sarkis et al. (2010), Halldorsson and Kovacs (2010), Edwards et al. (2010), Nikolaou et al. (2013), Vijayan et al. (2014), Boix et al. (2015)
Internal pressures	Hanna et al. (2000), New et al. (2000), Carter et al. (2007), Tapiero and Kogan (2008), Labuschagne and Brent (2008), Mont and Leire (2009), Gattiker and Carter (2010), Longoni et al. (2014)
Institutional pressures	Ketokivi and Schroeder (2004), Zhu et al. (2005), Zhu et al. (2007), Jayaraman et al. (2007), Ketchen and Hult (2007), Liang et al. (2007), Cai et al. (2010), Liu et al. (2010), Sarkis et al. (2011), Kang et al. (2012), Law and Gunasekaran (2012), Bhakoo and Choi (2013), Kauppi (2013), Coyle et al. (2014), Tseng and Hung (2014), Dubey et al. (2015a,b)
Social values & ethics	Roberts (2003), Beamon (2005), Drake and Schlachter (2008), Sarkis et al. (2010), Carter and Jennings (2002a,b), Hoejmose et al. (2013), Gold et al. (2010), Rokka and Uusitalo (2008), Mueller et al. (2009), Gloss et al. (2011), Gunasekaran and Spalanzani (2012), Eriksson (2015)
Corporate strategy & commitment	Carter and Dresner (2001), Griffiths and Petrick (2001), Narasimhan and Das (2001), McAfee et al. (2002), Mello and Stank (2005), Day and Lichtenstein (2006), Liang et al. (2007), Gattiker and Carter (2010), Hofmann (2010), Dey et al. (2011), Law and Gunasekaran (2012), Abdulrahman et al. (2014), Foerstl et al. (2015), Jabbour and de Sousa Jabbour (2016)
Economic stability	Rao and Holt (2005), Zailani et al. (2012), Wang and Sarkis (2013), Ortas et al. (2014), Wang and Sarkis (2013), Mitra and Datta (2014)
Green product design	Zhu et al. (2013), Linton et al. (2007), Dangelico and Pujari (2010), Sharma et al. (2010), Alblas et al. (2014)

Table 2
Structural self-interaction matrix (SSIM).

	V12	V11	V10	V9	V8	V7	V6	V5	V4	V3	V2	V1
V1	O	O	A	V	A	A	A	X	X	A	A	X
V2	A	A	A	O	O	X	A	V	O	V	X	
V3	O	O	A	A	X	A	A	V	A	X		
V4	A	O	A	O	V	V	V	V	X			
V5	A	V	A	A	A	A	A	X				
V6	O	O	A	O	V	A	X					
V7	A	O	O	O	V	X						
V8	O	O	A	A	X							
V9	X	A	A	X								
V10	V	A	X									
V11	X	X										
V12	X											

Identified variables of SSCM: **V1** – Economic stability, **V2** – Green Product Design, **V3** – Green warehousing, **V4** – Strategic supplier collaboration, **V5** – Environment conservation, **V6** – Continuous improvement, **V7** – Enabling Information Technologies, **V8** – Logistics Optimization, **V9** – Internal Pressures, **V10** – Institutional Pressures, **V11** – Social Values & Ethics, **V12** – Corporate strategy & commitment.

According to Warfield (1994) MICMAC Analysis is used to categorize variables in a complicated system. Mandal and Deshmukh (1994) explain that MICMAC will also help to analyze the driving power and dependence of variables of a complex system. According to Jharkharia and Shankar (2005), depending on the value of dependence and driving power the variables can be classified into four categories such as autonomous, linkage, dependent and independent barriers. The first category known as 'autonomous barriers' include the variables having weak driving as well as dependence power. MICMAC diagram for the variables of sustainable supply chain management under study is shown in Fig. 2, and there is no variable coming in the first quarter, which means that, there is no autonomous variable.

Table 3
Initial reachability matrix.

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
V1	1	0	0	0	1	0	0	0	0	0	0	0
V2	1	1	1	0	1	0	1	0	0	0	0	0
V3	1	0	1	0	1	0	0	1	0	0	0	0
V4	1	0	1	1	1	1	1	1	0	0	0	0
V5	1	0	0	0	1	0	0	0	0	0	0	0
V6	1	1	1	0	1	1	0	1	0	0	0	0
V7	1	1	1	0	1	1	1	1	0	0	0	0
V8	1	0	1	0	1	0	0	1	0	0	0	0
V9	1	0	1	0	1	0	0	1	1	0	0	1
V10	1	1	1	1	1	1	0	1	1	1	0	1
V11	0	1	0	0	1	0	0	0	1	1	1	1
V12	0	1	0	1	1	0	1	0	1	0	1	1

The variables coming in first quarter will not be have much connection with the system or with other variables. The variables V3, V5, and V8 are coming in second quarter that is known as 'dependent barrier'. Dependent barrier variables are having weak driving power and strong dependence power. Since these variables depend heavily on other variables, any change on other variables will affect these variables.

The ranking of variables into different levels is known as level partitioning. The reachability set and the antecedent set are found from the final reachability matrix (Warfield, 1974). Following Dubey and Ali (2014, p. 136), "the reachability set consists of the element itself and the other elements which it may help achieve, whereas the antecedent set consists of the element itself and the other elements which may help in achieving it." In any iteration, if the reachability set intersection antecedent set is the reachability set itself then those variables occupy the top levels of the hierarchy. The final output of level partitioning is shown in Table 5 below and the model is presented in Fig. 1.

4.3. Synthesis of TISM model and MICMAC analysis output

Following the tenets of TISM (Dubey and Ali, 2014; Dubey et al., 2015a,b) a synthesis of the TISM model and MICMAC analysis was conducted which resulted in a testable framework (Fig. 3). The particular framework can be tested via regression analysis, in which the driving drivers of SSCM practices are represented as independent variables and the dependent drivers as dependent variables. Our proposed framework is in accordance with Wacker's (1998) principles of good operations management theory in that it has (i) uniqueness, based on TISM and expert opinions as well as on a systematic literature review; (ii) parsimony, in that it does not contain many assumptions; (iii) conservation, in that it can

Table 4
Final reachability matrix.

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	Driving power
V1	1	0	0	0	1	0	0	0[a]	0	0	0	0	2
V2	1	1	1	0	1	1[a]	1	1[a]	0	0	0	0	7
V3	1	0	1	0	1	0	0	1	0	0	0	0	4
V4	1	1[a]	1	1	1	1	1	1	0	0	0	0	8
V5	1	0	0	0	1	0	0	0	0	0	0	0	2
V6	1	1	1	0	1	1	1[a]	1	0	0	0	0	7
V7	1	1	1	0	1	1	1	1	0	0	0	0	7
V8	1	0	1	0	1	0	0	1	0	0	0	0	4
V9	1	1[a]	1	1[a]	1	0	1[a]	1	1	0	1[a]	1	10
V10	1	1	1	1	1	1	1[a]	1	1	1	1[a]	1	12
V11	1[a]	1	1[a]	1[a]	1	1[a]	1[a]	1[a]	1	1	1	1	12
V12	1[a]	1	1[a]	1	1	1[a]	1	1[a]	1	1[a]	1	1	12
Dependence	12	9	10	5	12	7	8	11	4	3	4	4	

[a] Represents transitive links.

replaced by another framework that is superior in its virtue; (iv) generalizability, as the framework and theory building process can be applied to studies referring to SSCM drivers; (v) fecundity, in that it is should be fertile in generating new models and hypotheses, studying the relationships between the drivers; (vi) internal consistency, in that it identifies all relationships and gives adequate explanation of the SSCM drivers; (vii) empirical riskiness, since the theory could be refuted; and (viii) abstraction, as the framework is independent of time and space.

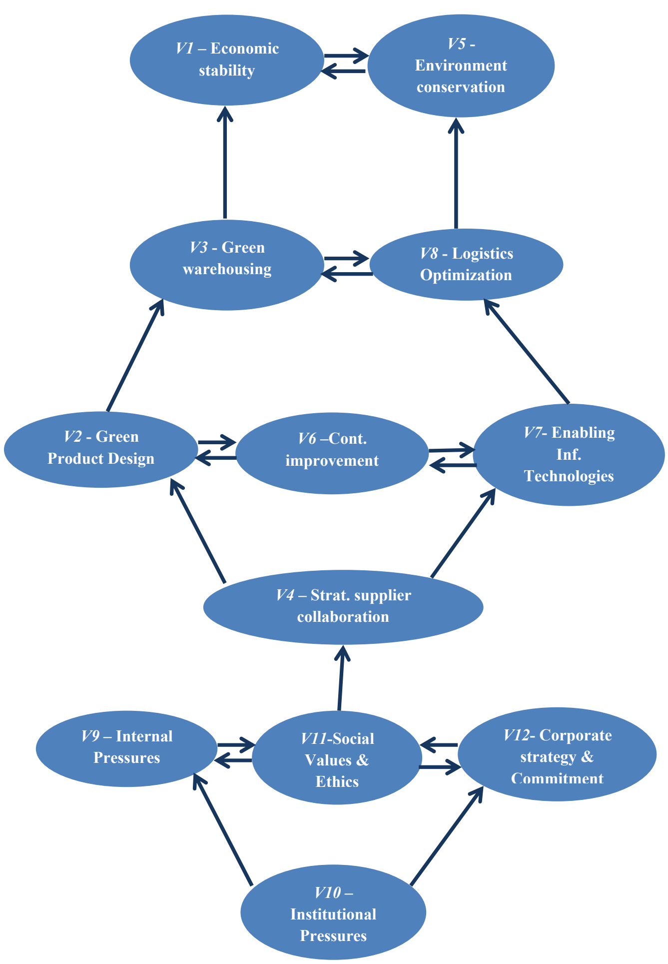

Fig. 1. Structural model.

5. Discussion

5.1. Implications for SSCM theory

This paper has a two-fold contribution to the SSCM literature. Firstly, it complements the efforts by scholars such as Ketokivi and Choi (2014) by offering an alternative approach to theory building (Eisenhardt, 1989; Eisenhardt and Graebner, 2007), in SSCM, that is, TISM, through strategic theoretical framework development. The study does not follow a dichotomist view on SSCM drivers and frameworks and does not make an argument for the adoption of only deductive empirical research (e.g. Markman and Krause, 2014), or case study approaches (e.g. Meredith, 1998; Pagell and Wu, 2009; Ketokivi and Choi, 2014). Our research proposes the use of TISM as bridging the aforementioned divide by generating theory (theoretical framework) based on a systematic review of the SSCM literature, but also based on opinions of experts and is tested.

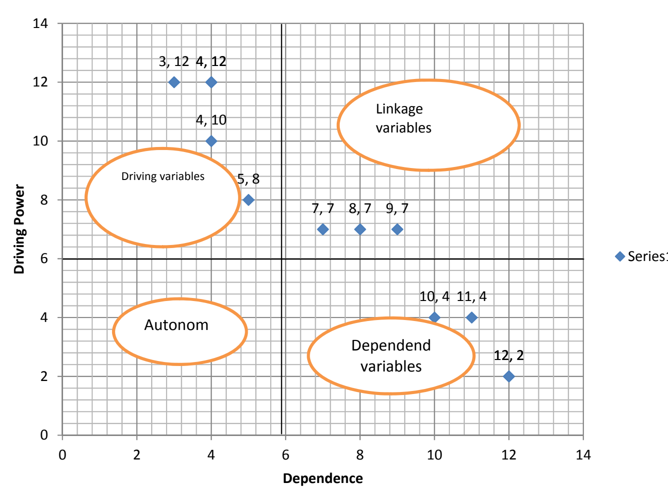

Fig. 2. MICMAC diagram.

Table 5
Level matrix.

V1, V5	Level 1
V3, V8	Level 2
V2, V6, V7	Level 3
V4	Level 4
V9, V11, V12	Level 5
V10	Level 6

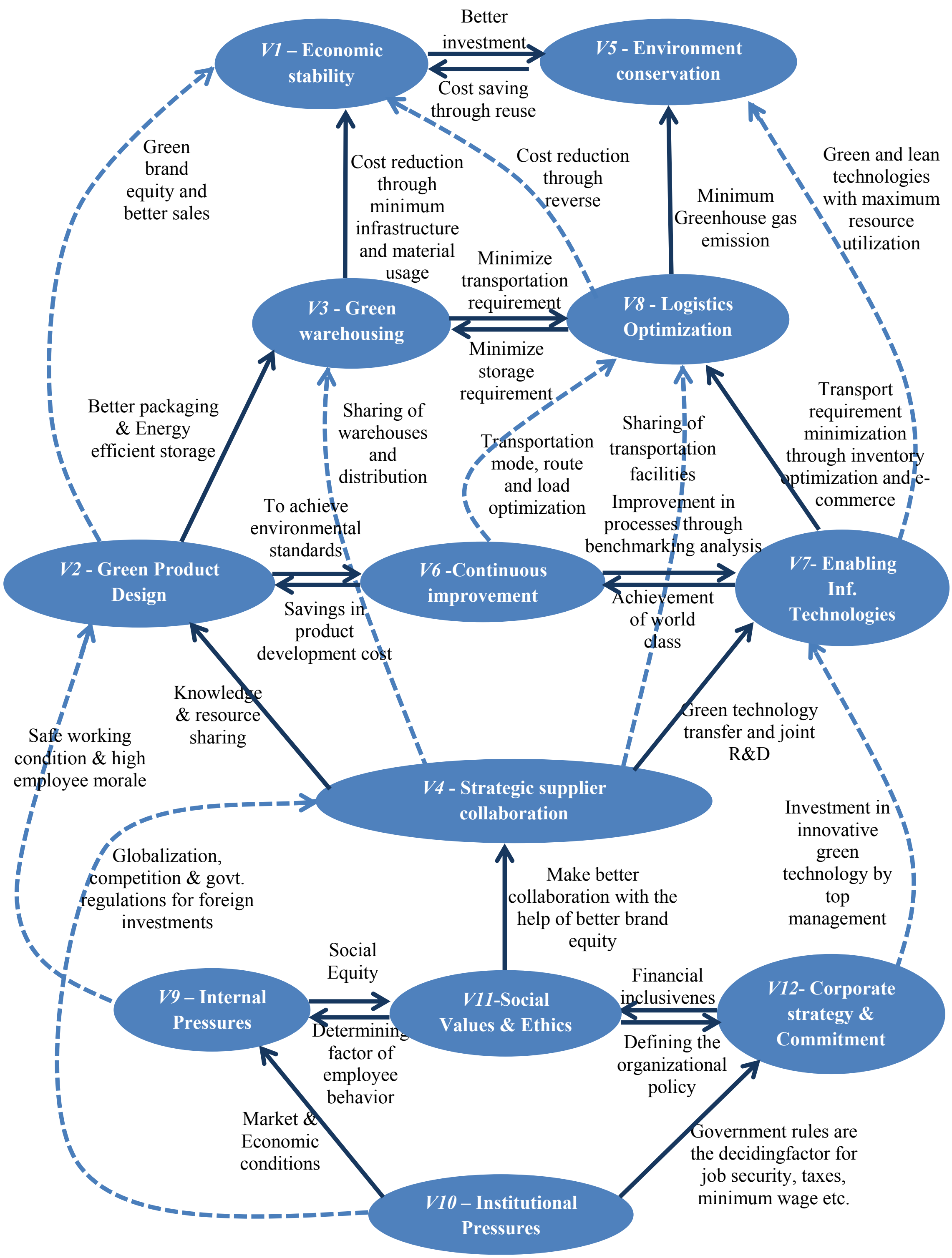

Fig. 3. The TISM model.

Hence, we overcome the challenges related to deductive approaches, but also of those related to case study research, that is, "ambiguity of inferred hypotheses" and the "selective bias" (Bitektine, 2008: 161; Barratt et al., 2011). Secondly, this research extends the extant literature on SSCM (e.g. Walker and Jones, 2012; Ahi and Searcy, 2013; Diabat et al., 2014) by offering a strategic framework that is based on both the literature and experts' opinions on the drivers of SSCM. The framework extrapolates 12 drivers and their relationships, highlighting in particular the role of institutional pressures (Ketokivi and Schroeder, 2004; Ketchen and Hult, 2007; Liu et al., 2010; Sarkis et al., 2011; Bhakoo and Choi, 2013; Kauppi, 2013), internal pressures (Carter et al., 2007; Paggell and Gobeli, 2009; Gattiker and Carter, 2010) and top management commitment (Liang et al., 2007; Gattiker and Carter, 2010; Abdulrahman et al., 2014; Foerstl et al., 2015; Jabbour and de Sousa Jabbour, 2016) in determining, inter alia, strategic collaboration with suppliers (Vachon and Klassen, 2008; Dam and Petkova, 2014; Glover et al., 2014) and ultimately the formulation of the corporate SSCM strategy to achieve economic stability and address environmental concerns of the organization or supply chain.

5.2. Implications for SSCM managerial practice

Our study has implications for SSCM managerial practice, in terms of offering guidelines on those factors that managers should pay attention to in order to adopt SSCM practices in their organizations and supply chains. In particular, our study underlines the role of institutional pressures on internal pressures and commitment. Therefore, managers should be aware on how to 'translate' these pressures into appropriate strategies and strategic collaboration with suppliers in order to achieve sustainability. The role of green product design as enabled by continuous improvement is important, and information needed for this purpose could be provided by appropriate information technologies. Logistics and warehousing should be also improved, and particular changes in these operations will enable organizations and supply chains become more environmentally friendly, and will also help them become economically viable and stable. Paying attention to these drivers means acquiring and cultivating particular employee skills; hence, this study proposes that managers should also attend to the different skills and capabilities needed to achieve SSCM, as determined by the proposed drivers. The proposed framework can be perceived as a strategy that will enable companies achieve SSCM; it can be also a tool that will help organizations (i) diagnose their current situation through assigning importance factors (or weights) to each of the drivers of SSCM and (ii) evaluate their SSCM strategy and these drivers to check whether there are factors where they need to be improved in order to achieve full realization of their strategy and hence competitive advantage.

6. Conclusions

This study is an attempt to develop a theoretical framework to explain the complex interactions of variables in the dynamic environment of SSCM by using the TISM technique. Since the number of publications in TISM is very limited, this study will help researchers to understand the use of TISM as a powerful methodology for conceptual framework development. Thus, the current study is analyzing the drivers in the adoption of eco-friendly technologies and environmentally inspired processes for ensuring benefits to the society it operates by achieving long term economic stability in the supply chain management operations of an organization. The sustainable supply chain theoretical frame-work developed by using TISM helps to describe the dynamic interactions of product design, enabling technologies, and environment conservation strategy to attain better brand equity, cost savings and competitiveness through a total systems approach. TISM model also help to clearly understand the transitive linkage between the drivers and clearly depicts the actions that are to be taken to attain the desired level in the hierarchy. The results of our present study give the right direction to the supply chain managers in the journey towards sustainability. The result shows that institutional pressures and ethics and values of the society influence the competitiveness of any firm. The environmental conservation is enabled by institutional pressures and is made actionable by supply chain professionals by focusing on green operations through green technology and design. Focus on green technologies, product design, warehousing and logistics further helps the firm to improve the green brand image and brand equity, which in turn will help to improve customer demand and cost savings and will ultimately lead to have better economic stability and profitability, which will further strengthen firm.

In this study we have not used a structured questionnaire to further test the framework. Instead we relied completely on a survey of the perceptions of experts for developing the theoretical model, which alone may not be sufficient to statistically test the framework, and this is a limitation of the TISM method. But according to the aim of this study, we set off to develop a theoretical framework by TISM. For future research, a structured questionnaire could be prepared and a survey must be conducted by targeting highly experienced supply chain professionals, who embrace sustainability thinking in their operations to test the framework. Furthermore, the study can be further extended to build a theoretical framework on ethical SSCM by incorporating some additional soft dimensions. Confirmatory factor analysis can be done to test the SSCM theoretical framework developed. MICMAC analysis can be improved by incorporating the fuzzy set concept to overcome the limitations of the existing analysis by using '0 and 1'. Fuzzy input assumes intermediate values between '0 and 1', which may help to improve the sensitivity and to understand the intensity of relationship between variables. We believe that our study provides useful thoughts for those who would like to further engage into theory building on the drivers of SSCM.

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