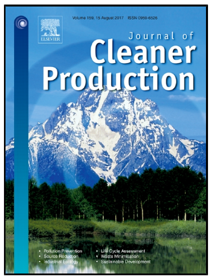

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Knowledge management in sustainable supply chain management: improving performance through an interpretive structural modelling approach

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Abstract

Sustainable supply chain management is one vital element in achieving competitive advantage in business management and knowledge management is seen to be one key enabler. However, in previous studies the interrelationships between knowledge management and sustainable supply chain management are still under-explored. This study proposes a set of measures and interpretive structural modelling methods to identify the driving and dependence powers in sustainable supply chain management within the context of knowledge management, so as to improve the performance of firms from the textile industry in Vietnam. The research result indicated that learning organisation, information/knowledge sharing, joint knowledge creation, information technology and knowledge storage are amongst the highest driving and dependence powers. These attributes are deemed to be most-effective to enhance the performance of firms. To further enhance the value of this research, theoretical and managerial implications are also discussed in this study.

Keywords: knowledge management; sustainable supply chain management; interpretive structural modelling

1. **Introduction**:

Sustainable supply chain management (SSCM) is playing an important role in business management (Seuring & Müller, 2008). Since business environment is dynamic and volatile, it creates the necessity for firms to enhance their profitability and sustainability to achieve their competitive advantage (Zailani *et al*, 2012). Not an exception, textile industry is one of the largest industries and is adopting sustainable management concepts in their supply chain. Therefore, this study focuses on the Vietnam textile industry which is a rapid growing industry in the country producing a vast variety of garments to meet customer needs and is experiencing increasing environmental concerns. Textile firms need to focus on sustainability concerns in their supply chain due to the pressure of achieving stakeholders' goals. Hence, there is an increasing expectation to expand the sustainability efforts beyond their in-house operations to suppliers and customers in the supply chains (Porter & Kramer, 2006).

In the literature, a number of SSCM frameworks have been proposed (Govindan *et al*., 2013; Tseng *et al*., 2015). The recent studies have identified the influential attributes to address and evaluate the SSCM on firm's performance (Zailani *et al*., 2012). The triple bottom line (TBL), which incorporates social, environment and economic aspects, has been popular and widely adopted to approach sustainability (Ahi & Searcy, 2013; Tseng *et al.,* 2015). These were stated as three crucial performance aspects for measuring sustainability (Seuring & Müller, 2008, Zailani *et al.,* 2012). In addition, it is evident that SSCM requires rethinking in relation to TBL deploying intangible resources, such as knowledge to improve firm's performance (Dyllick and Hockerts, 2002). Thus, managing knowledge is deemed to be critical to achieve sustainable competitive edge in supply chain management. Knowledge management (KM) transforms information, data and intellectual assets to firms' perdurable value through recognising useful knowledge for running and managing operations. Hence, KM in SSCM is considered as a fit strategy to achieve their competitiveness and sustainability. However, there is still a gap to address, which very few studies have dealt with, in relation to the interrelationships amongst the attributes (Samuel *et al.,* 2011). Therefore, the core aim of this study is to identify the key and driving attributes of KM in SSCM.

This study adopted interpretive structural modelling (ISM) to define the hierarchical interrelationships amongst the attributes, which has been widely proven as a promising qualitative tool to determine the structure of any social or technical system with related identifiable attributes. The proposed methodology takes in the interrelationships amongst the attributes to identify the driving and dependence powers in supply chain management and analyse on the basis of the degree of influence they have on one another. Hence, the research questions to address are as follows:

- What are the interrelationships among the attributes?
- What are the driving and dependence powers to improve the firms' performance through KM in SSCM?
- What is the SSCM action plan for next frontier?

Furthermore, this study also contributes to the literature of KM in SSCM by providing theoretical insights through identifying a structured set of attributes and providing comprehensive empirical findings in textile industry. The remaining of this paper is organised as follows. Section 2 analyses the relevant literature and discusses the proposed methodology and evaluation measures. Section 3 describes the methodology used in this study and the research findings will be presented in Section 4. Section 5 discusses the theoretical and managerial implications. Finally, a conclusion of this study will be provided in Section 6.

2. Literature review

This section included KM related to SSCM, SSCM and proposed methodology. A set of measures is also discussed.

2.1 Knowledge management

Prior studies have discussed the contribution of KM within supply chain field. Samuel *et al.* (2011) has demonstrated that this study stream has rapidly developed over the past few years and is still being investigated by the practitioners and academicians. Spekman *et al.* (2002) has argued that effective supply chain management requires effective KM to achieve competitive advantage, especially when extending from an individual firm to embrace the supply chain network. However, despite the notion of knowledge being relatively straight forward to understand, complication and confusion could be raised when it is applied across a wide range of disciplines. Duhon (1998) defined KM as an integrated approach to identify, capture, evaluate, retrieve, and share all information, and this information could be in the forms of database, document, policy, procedure, and formerly uncaptured expertise and experience in individual workers. It was also seen as a process of creating, acquiring and transferring knowledge that is reflected in the behaviour of the organisation (Bueno *et al.,* 2010). Furthermore, Bloodgood (2009) referred KM as the creation, storage and utilisation of routines. Therefore, it brings concern to the creation, storage, dissemination, and application of organisational knowledge within the supply chain.

It has been noted that sustaining competitive advantage shall not merely be based on just the accumulation of knowledge (Sambasivan *et al.,* 2009). The capability of KM in industry is utmost important when attempting to implement sustainable practices in the supply chain. KM is argued as an indispensable ingredient for the development of dynamic core competencies and, more generally, as a determinant attribute for firms with global ambitions (King & Zeithalm, 2003). Moreover, KM in SSCM is a practical strategy of delivering knowledge to the right people at the right time and is providing a platform whereby people share and transform information into actions to achieve organisational competitiveness (Lindblom & Tikkanen, 2010). Hence, the development of a sustainable supply chain depends on knowledge transfer and the capabilities amongst supply chain partners. Furthermore, it is also seen as a facilitation of application and development in organisational knowledge to create new value and enhancing SSCM. Consequently, practising KM in SSCM ensures that the most reliable, accurate knowledge is utilised efficiently, leading the best products and services being offered (Sambasivan *et al.,* 2009).

Through this, the experience and knowledge of best practices can be efficiently stored and in good use throughout the supply chain operations. KM drives supply chain development and is likely to be applied to introduce innovation in SSCM. Furthermore, the flow of knowledge between groups with diverse purposes and practices is difficult to manage either within an organisation or between partners within the same supply chain (Samuel *et al.,* 2011). As a result, the ability to create, combine, configure and share knowledge as fast and much as possible with as many groups/partners as possible has become the sustainable competitive positioning in the global market (Sambasivan *et al.,* 2009). However, to achieve SSCM, any firm must possess and share knowledge of many different attributes of their supply chains, and the lack of knowledge amongst the supply chain partners can affect the overall supply chain performance. Hence, KM is a critical component to achieve SSCM.

2.2 Sustainable supply chain management

Dyllick & Hockerts (2002) presented SSCM as an integration of sustainable development and supply chain management, whereas Seuring & Müller (2008) defined SSCM as the management of material, information and capital flows, and co-operation between firms in the supply chain while taking into account of the goals from sustainable development derived from the relevant parties' requirements. Carter & Rogers (2008) proposed this issue as the strategic, transparent integration and achievement of an organisation's goals through the system of cooperated business operations to improve the economic, environment and social performance of the individual firm and their supply chain. Firms that approach SSCM also place an important focus on decisions marking as an orientation to succeed for managing their supply chain. A sustainable supply network defines the way supply chain partners interact on permanent level which is used to construct long-term relationships to help to develop and select qualified partners (Pagell & Wu, 2009).

Moreover, by engaging stakeholders, firms are able to address potential pressure and obtain advantages from stakeholder knowledge (Pagell & Wu, 2009). However, multiple attributes of SSCM still need multi-functional operations to achieve competitive advantage in intensive competitions as well as to address challenges to present various attributes to facilitate the attainment of competitive changes (Su *et al.,* 2015). SSCM is practised by applying critical success attributes which are crucial for achieving high performance for any strategy implementation and individual project success. Zailani *et al*. (2012) indicated that SSCM is a promising factor in relation to the sustainable performance of supply chain, particularly from the perspectives of economics and social, while Murphy & Poist (2002) posited the standalone activities within social issue and noted the need to "*seek socially beneficial results along with economically beneficial ones*". Carter & Rogers (2008) proved that, at the horizontal supplier-supplier relationships level, desirable supplier groups can only be formed if there exists a channel for horizontal collaboration on sustainability to compare between different suppliers' level of performance. This includes reporting to stakeholders, engaging with them and based their input to secure buy-in and improve supply chain operations.

SSCM is also intended to improve business and environmental performance in the supply chains (Lin & Tseng, 2014, Chan *et al.,* 2015). Ahi & Searcy (2013) suggested that firms need to address the sustainability concerns in their supply chain because of the increasing attention of environmental issues in conventional activities. SSCM also helps managers to develop effective strategies to adopting technologies to contribute to the profitability (Laboy-Nieves *et al*., 2010). Besides, Eltayeb *et al.* (2011) proved that environmental management systems are necessary in SSCM which can be seen as a standard that could adopt for better performance. Hence, a good environmental management means forming a policy to promote combination amongst environmental dimension products, operation, and organisational strategies.

2.3 Proposed methodology

Previous studies have proposed some methodologies to analyse SSCM. For instance, Govindan *et al.* (2013) used a fuzzy multi-criteria approach to measure sustainability performance of suppliers based on TBL approach and Lin & Tseng (2014) applied interval-valued triangular fuzzy method to represent the linguistic preferences and utilised multi-criteria decision making to assess the hierarchical structure through recognising the competitive priorities and the trade-offs within SSCM. Su *et al.* (2015) used a novel hierarchical grey-DEMATEL (Decision Making Trial and Evaluation Laboratory) in SSCM. It is obvious that these studies have widely adopted quantitative, survey based approaches and classical statistical methods in this context. However, the attributes of SSCM has a vital role in filtering suppliers, which involve more interrelationships simultaneously (Lee *et al.,* 2009).

According to Tseng *et al*. (2008), modified ISM is more capable of handling problems of dependence of criteria and linguistic preferences with an appropriate hierarchical structure due to its enriched information for strategic direction. Hence, this study applied ISM approach to identify the driving attributes in SSCM and to study the interrelationship amongst them. In ISM approach, a set of elements are structured into a comprehensive systemic model that identifies the influence and determines the direction and order amongst the attributes of the system. As a result, the interrelationship amongst the attributes can be represented in a hierarchical manner that classifies them on the basis of the degree of influence they have on one another.

Previous studies have adopted ISM for various research domains, such as Mangla *et al.* (2014) developed an ISM-based approach to implement and initiate green activities in supply chain and Bouzon *et al.* (2015) conducted this methodology to analyse the interactions between the barriers that hinder reverse logistics development. Based on its popularity and proven successful applications in the literature, it is convinced that ISM would be an effective approach for our study to address KM in SSCM.

2.4 Proposed evaluation measures

In the literature, research studies in SSCM have proposed different evaluation models and frameworks (Tseng *et al.,* 2015; Govindan *et al.,* 2013). SSCM attributes play a critical role in filtering and selecting suppliers, which consider TBL interrelationships simultaneously (Lee *et al*., 2009; Su *et al.,* 2015). Moreover, they performed well on both traditional and the expanded conceptualisation of performance (Pagell & Wu, 2009). Hence, this study proposed 21 criteria from four aspects, i.e. economic, environment, social and KM (see Table 1) for measuring processes.

The concern of economic is still the priority of managers for SSCM to assure the competitive advantage. Previous studies have proposed *manufacture* (C1) focuses on production stages to eliminate the expensive manufacturing processes and materials to ensure process feasibility and provide cost estimation (Holt & Barnes, 2010). *Logistics integration* (C2) refers to specific logistics practices and operational activities that coordinate the flow of materials from suppliers to customers throughout delivering value, hence, building competitive advantage (Stock & Wright, 2000). Stevenson & Spring (2007) suggested that *sourcing flexibility* (C3) is the ready capability of the supply chain architecture to cope and realign the chain in response to market uncertainties and changes, to rapidly exchange products cost information effectively, and to configure information systems with existing supply chain entities to meet changing information needs. *Product quality* (C4) refers to a firm and its supply chain partners offering quality of product that creates high value for customers (Gray & Harvey, 1992). *Innovation* (C5) is associated with the development of new ideas/solutions and the introduction of administrative or organisational technological changes in the processes (Lundvall, 2010).

Product life-cycle (C6) focuses on environmentally friendly practices through the need, design, production, distribution, usage, disposal, and recycling, and assigned costs to the firm, user, or society (Fiksel & Wapman, 1994). According to Kjaerheim (2004), *cleaner production* (C7) means using any resources required to efficiently eliminate toxic raw materials and to reduce the amount of toxicity of all emissions and wastes before they exit the production. *Law and regulations* (C8) are based on the concept of extended producer responsibility, which mandates the manufacturers to internalise product externally, and converts an open-loop supply chain of the production and distribution into a closed-loop supply chain that encourages recycling, reuse and improving product design (Ji *et al.*, 2014). Meanwhile, *waste minimisation and recovery* (C9) refers to minimising waste generated from the products, and if possible make waste recoverable (especially for recycling, energy creation, etc.) (Fiksel, 1996; Hart, 1997). *Recycling (or reverse logistics)* (C10) is related to the process of planning, implementing, and controlling the efficient flow of raw materials, inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of reproducing value or for disposal (Rogers & Tibben-Lembke, 1999). *Green purchasing* (C11) relates to purchasing items with desirable environmental attributes, such as reusability, recyclability, and has influence on the resource mix as well as the absence of hazardous materials. It determines the choice of suppliers by environmental criteria which include environment-friendly raw materials, pressuring suppliers to take environmental actions (e.g. qualitative supplier control and auditing), and also supports its supplier development programmes (Eltayeb *et al.,* 2011; Tseng & Chiu, 2013).

Although social is considered as a complex aspect of sustainability, it is rarely taken into consideration in SSCM models. In this study, five criteria, namely social responsibility, work conditions, communication, collaboration and transparency are proposed to provide a more in-depth understanding of this aspect. *Social responsibility* (C12) represents a global indicator used to assess a firm's social performance by evaluating the social consequences of their activities that do not impose harm on particular communities and support humanity (Chardine-Baumann & Botta-Genoulaz, 2014). *Work conditions* (C13) is related to improving the standard of living, by providing full and stable employment, and moreover, to evaluate the impacts of practices on work conditions and social welfare (e.g. salaries, compensations, vacations, disciplinary practices, and dismissals and maternity protection issues, and so on) (Chardine-Baumann & Botta-Genoulaz, 2014). In addition, *communication* (C14) is the message transmission process amongst supply chain partners in terms of frequency, direction, mode and strategy (Cao & Zhang, 2011). De Bakker & Nijhof (2002) also argued that *collaboration* (C15) is an essential criterion involving coordination between the firm and its suppliers, customers, or other stakeholders to jointly improve social outcomes. In recent years, local communities and external stakeholders are becoming more and more demanding for corporate practices to more visible and *transparent* (C16) to maintain their legitimacy and reputation (Hart, 1997).

In KM, a *learning organisation* (C17) contributes to the resource and knowledge-based views on supply chains and leads to competitive advantage (Moorman & Miner, 1997; Gulati, 1999). *Information sharing* (C18) allows supply chain partners to improve forecasting, synchronise production and delivery information, coordinate inventory-related decisions, and hence able to possess a shared understanding of their performance impacts (Lee & Whang, 2000; Chen *et al.,* 2000). Malhotra *et al.* (2005) have proposed *joint knowledge creation* (C19) referring to the supply chain partners jointly develop a deeper understanding of the market and corresponding responses to the competitive environment. Then, *information technology* (C20) significantly enhances the firm's ability to capture, process, and share information across the supply chain for coordinating and creating synergy, thus improving the effectiveness, facilitating operations, and reducing communication and transaction cost (Muller & Seuring, 2007; Vickery *et al.,* 2010). Based on this, *knowledge storage* (C21) refers to creating a shared space, in which employees can observe and learn the actions of their workmates and what they can contribute to (Van Joolingen *et al.*, 2005).

3 Methodology

This section, firstly, discusses the textile industry in Vietnam and addresses the need of improving its performance to achieve the SSCM. Secondly, the ISM methodology is discussed in detail, and finally, the proposed analysis steps are introduced.

3.1 Industrial background

In Vietnam, textile industry is a leading industry with 15% growth per year and annual export turnover from 10% to 15% of GDP in the last decade. However, the industry is still using basic manufacturing processes and is lack of essential supply abilities which result in low value-added activities. Furthermore, this industry always faces the challenge of coping with dynamic changes of customer demands in styles and in quantity, resulting from the complicated and unpredictable global fashion market (Ngai *et al.,* 2014). As globalisation, as well as the change of marketing techniques, consumption trends, and modern technology has incorporated SSCM in recent years, the industry is facing greater difficulties and challenges in integrating international market, intensive competitions, trade barriers and environmental issues (Zanoni & Zavanella, 2012). Thus, this industry is characterised by unpredictable demand, short product life cycles, quick response times, large product variety, and a volatile, inflexible, and complex supply chain structure. The industry is commonly exposed to some shortcomings, such as the imbalance in the supply chain and auxiliary raw materials imported. Therefore, there is a growing need to reorganise the supply chains to be more sustainable in order to enhance the value of export sectors, and KM can plan an important enabler in this development. Hence, this study was carried out to help the textile industry understand in greater depth in regard to the attributes which drive the supply chains of the industry, in particular from the sustainability's perspective.

The study is focussing on the experts or managers who have reasonable years of experience in textile industry. The measurement process was designed in 2 stages. In Stage 1, the attributes were found by searching the literature. In Stage 2, the data was collected from around textile firms in Vietnam who are operating with business location in the whole country. A group of 20 experts including professional managers with extensive consulting experience was formed to be the study's respondents.

3.2 *Interpretive structural model (ISM)*

ISM is a method involving qualitative and interpretive to resolve complex problems based on a structural mapping of interconnections of attributes, and followed by transforming them into a multi-level structural model (Watson, 1978). The basic idea is based on the experts' practical experience as well as knowledge to decompose a complex system into several sub-systems in which a multi-level structure model can be built (Mathiyazhagan *et al.,* 2013). This method identifies the influence and explains the direction amongst the attributes of the system. In addition, it also establishes the relationships amongst specific attributes in order to define a problem/issue by means of their dependency and driving power (Mangla *et al.,* 2014). Due to its capability, ISM is a popular tool amongst academicians for analysing the interrelationship attributes.

The ISM method was implemented as follows:

The methodology suggested uses the opinions of expert based on different management techniques, e.g. brainstorming and nominal technique, in developing the interrelationship amongst the attributes. Thus, for identifying this interaction, experts from the industry and academia were consulted. Four symbols are utilised to indicate the sort of connection amongst them (*i* and *j*).

- V: For the relation from *i* to *j*, but not in both direction
- A: For the relation from *j* to *i*, but not in both direction
- X: The relationship between *i* and *j* is in both direction
- O: When both the attributes *i* and *j* are unrelated

By substituting V, X, A and O by 1 and 0, and incorporating transitivity, the dependence and driving power of each criterion shows initial reachability matrix. The substitution rules of 1 and 0 are summarised as:

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

The reachability set for an individual's attribute consists of itself and the other attribute which it also tries to achieve, while its antecedent set consists of the attribute itself and the other attribute which may also try in achieving it. In other words, the driving power of a particular attribute is the total number of attributes (including itself), which it may try to achieve while the dependence number is the total number of attributes, which may try achieving it (Ravi *et al.*, 2005). The criterion for which its reachability was set to equal to its intersection set is identified as the top-level in the ISM hierarchy. One important feature of the top-level criterion in the hierarchy is that it does not help to achieve any other criteria above its own level. Therefore, once the top-level is identified, it will be separated from other criteria. The same process is repeated to explore the next level until the level of each criterion was found. Then, the identified levels of the attributes are used in building the diagraph and the final model of ISM.

These symbols consist of an initial reachability matrix of qualitative information and then transformed into binary codes to attain a reachability matrix. The reachability set and antecedent set can be acquired from the final reachability matrix, in turn aggregating the individual reachability matrix into a total reachability matrix. $ReM^x = [rm_{ij}]_{nxn}$ represents the n^{th} expert's individual reachability matrix. The computation of total reachability matrix R^T must be applied through the following equations.

$$R^T = \frac{1}{n}\left(rm_{ij}^1 + rm_{ij}^2 + \cdots + r_{mij}^{n}\right), i,j = 1,2,3,\cdots n \quad (1)$$

After generating a diagram, the reachability $(Re^{'})$ and antecedent $(At^{'})$ sets must be determined from the total reachability matrix as follows:

$$r_i = 1, Re^{'} = \left\{rm_1^{Re^{'}}, rm_2^{Re^{'}}, \cdots rm_n^{Re^{'}}\right\}; \quad (2)$$

$$r_j = 1,\ A^{'} = \left\{rm_1^{At^{'}}, rm_2^{At^{'}}, \cdots rm_n^{At^{'}}\right\} \quad (3)$$

The intersection set $I^{'}$ can be generated as follows:

$$I^{'} = R^{'} \cap A^{'} \quad (4)$$

The intersection set was derived from overlapping criteria. This reveals the amount of overlapping criteria of higher value needed for the upper levels of the ISM hierarchy. The criterion at the top of the hierarchy cannot facilitate criteria above its own level. Once the highest level is confirmed, the criteria are separated from the other criteria. This process is repeated until all criteria are arranged into separate hierarchical levels.

3.3 Proposed analytical steps

The steps involved in ISM methodology are illustrated as below.

Step 1: List the attributes under consideration. The attributes which may affect the performance are listed and filtered through a comprehensive literature review for its validity.

Step 2: Collect the structural self-interaction matrixes (SSIM). The contextual relationships of criteria are assessed by the experts' opinions. Each expert has his/her own SSIM and the interactions amongst experts will be avoided.

Step 3: Generate reachability matrix once the collection process of SSIM is complete. This will transform the qualitative judgments into binary codes. Thus, these binary codes consist of the individual reachability matrixes.

Step 4: Develop and partition the levels of reachability matrix. This converts individual reachability matrixes from experts and aggregated into a total reachability matrix. This aggregation process utilises an average method to avoid the extreme value in judging the relationships.

Step 5: Build the ISM model. As elaborated in the ISM methodology, the structural model of the criteria is constructed using the level partition and the final digraph is developed by eliminating the transitivity.

Step 6: Construct driving and dependence power diagram after acquiring the total reachability matrix, where taking driving power as horizontal axis and dependence power as vertical axis.

4 Result and Discussion

This section discusses the six-step approach used in the ISM analysis in this study.

Step 1: List the attributes

The ISM methodology collects views and inputs from the experts/managers through brainstorming and nominal group technique in relation to the four aspects of key attributes for SSCM. To maintain confidentiality, names of the experts will not be disclosed in this paper. After the brainstorming sessions, twenty-one criteria were identified as listed in Table 1. To concur the criteria identified based on the experts' feedback; associated literature works are also included in the table.

Table 1. Proposed measurement criteria

Aspects	Criteria		Literature review
Economics (A1)	C1	Manufacture	Holt & Barnes (2010)
	C2	Logistics integration	Stock & Wright (2000)
	C3	Sourcing flexibility	Stevenson & Spring (2007)
	C4	Quality	Gray & Harvey (1992)
	C5	Innovation	Lundvall (2010)
Environment (A2)	C6	Product life-cycle	Fiksel & Wapman (1994)
	C7	Cleaner production	Kjaerheim (2004)
	C8	law and regulations	Ji *et al.* (2014)
	C9	Waste minimisation & recovery	Fiksel & Fiksel (1996), Francis (1997), Hart (1997)
	C10	Recycling (reverse logistics)	Rogers & Tibben-Lembke (1999)
	C11	Green purchasing	Eltayeb *et al.* (2011), Tseng & Chiu (2013)
Socials (A3)	C12	Social responsibility	Porter & Kramer (2006),
	C13	Work conditions	Baumann & Genoulaz (2014)
	C14	Communication	Cao & Zhang (2011)

	C15	Collaboration	de Bakker and Nijhof (2002)
	C16	Transparency	Hart (1997)
	C17	Learning organisation	Moorman & Miner (1997), Gulati (1999)
Knowledge management (A4)	C18	Information/knowledge sharing	Lee & Whang (2000), Simchi-Levi et al. (2000)
	C19	Joint knowledge creation	Malhotra *et al*. (2005)
	C20	Information technology	Muller & Seuring (2007), Vickery *et al*. (2010).
	C21	Knowledge storage	Van Joolingen *et al.* (2005)

Step *2: Construct Structural Self-Interaction Matrix (SSIM)*

This step of ISM analysis is to perform analysis on the contextual relationship of attributes. Based on the consensus from the expert panel, the interrelationships in SSIM were constructed in Table 2 in relation to the 21 criteria identified. To establish a contextual interrelationship amongst the recorded criteria, the opinion of experts was in favour in order to determine how a specific criterion encourages others. For instance, transparency (C16) leads to law and regulations (C8), therefore the notation V was assigned to this relationship. As for quality (C4) and collaboration (C15), C15 is preceding C4, so the notation A was given for C15 and C4 relationship. While in the case of knowledge storage (C21) and social responsibility (C12), they have an interactive relation, so the notation X was given. Transparency (C16) is not related to manufacture (C1), hence the notation O was assigned to this relationship.

Table 2: Structural self-interaction matrix

Criteria		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
C21	Knowledge storage	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-	
C20	Information tech.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-		
C19	Joint knowledge creation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-			
C18	Knowledge sharing	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-				
C17	Learning organisation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-					
C16	Transparency	O	O	O	O	O	O	V	V	V	V	V	V	V	V	-						
C15	Collaboration	X	O	A	V	V	V	O	O	O	O	V	V	V	-							
C14	Communication	O	O	O	O	O	O	O	O	O	O	V	V	-								
C13	Work conditions	A	O	V	V	A	A	O	O	O	O	A	-									
C12	Social responsibility	V	O	O	O	O	A	A	A	A	A	-										
C11	Green purchasing	X	A	A	X	X	X	X	X	X	-											
C10	Recycling	X	X	O	X	X	X	X	X	-												
C9	Waste minimisation & recovery	X	X	V	A	X	X	X	-													
C8	Law and regulations	V	O	V	A	X	X	-														
C7	Cleaner production	X	X	X	X	X	-															
C6	Product life-cycle	X	X	X	X	-																
C5	Innovation	X	X	X	-																	
C4	Quality	V	O	-																		
C3	Sourcing flexibility	A	-																			
C2	Logistics integration	V	-																			
C1	Manufacture	-																				

Step *3: Generate Reachability Matrix*

Next, the SSIM is transformed into binary matrix, known as initial reachability matrix, and this is done by substituting the arrows A, O, V, X by 1 and 0 and incorporating transitivity, which is shown in Table 3. The table also shows the dependence and driving power of each criterion.

Table 3: Initial reachability and indicate transitivity matrix

Criteria		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**Driving power**
C1	Manufacture	1	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	17
C2	Logistics integration	0	1	0	1	1	1	1	0	1	1	1	0	0	0	1	0	1	1	1	1	1	14
C3	Sourcing flexibility	1	1	1	0	1	1	1	0	1	1	0	0	0	0	0	0	1	1	1	1	1	13
C4	Quality	0	0	0	1	1	1	1	1	1	0	0	0	1	0	0	0	1	1	1	1	1	12
C5	Innovation	1	1	1	1	1	1	1	0	0	1	1	0	1	0	0	0	1	1	1	1	1	15
C6	Product life-cycle	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	17
C7	Cleaner production	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	17
C8	law and regulations	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	13
C9	Waste Minimisation & Recovery	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	16
C10	Recycling (reverse logistics)	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	16
C11	Green purchasing	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	16
C12	Social Responsibility	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	14
C13	Work conditions	1	0	0	0	0	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	13
C14	Communication	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	8
C15	Collaboration	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	11
C16	Transparency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	6
C17	Learning organisation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
C18	Information/knowledge sharing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
C19	Joint knowledge creation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
C20	Information technology	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
C21	Knowledge storage	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
Dependence power		15	15	13	12	16	17	18	14	16	16	15	8	8	8	13	14	21	21	21	21	21	

Step 4: Partition the levels of reachability matrix

From reachability matrix, the intersection was derived for all criteria. Table 4 summarises the results for the interaction process. Criteria found at level 1 are the top-level position in the ISM Model.

Table 4: Partition the levels and conical matrix

Criteria		*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*Amount*	*Level*
C1	Manufacture	1	0	0	0	1	1	1	0	1	1	1	0	0	0	1	0	1	1	1	1	1	13	5
C2	Logistics integration	0	1	0	0	1	1	1	0	1	1	1	0	0	0	1	0	1	1	1	1	1	13	5
C3	Sourcing flexibility	0	0	1	0	1	1	1	0	1	1	0	0	0	0	0	0	1	1	1	1	1	11	4
C4	Quality	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	9	3
C5	Innovation	1	1	1	1	1	1	1	0	0	1	1	0	0	0	0	0	1	1	1	1	1	14	6
C6	Product life-cycle	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	16	8
C7	Cleaner production	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	16	8
C8	law and regulations	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	11	4
C9	Waste Minimisation & Recovery	1	1	1	0	0	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	14	6
C10	Recycling (reverse logistics)	1	1	1	0	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	15	7
C11	Green purchasing	1	1	0	0	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	14	6
C12	Social Responsibility	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	1	1	6	1
C13	Work conditions	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	6	1
C14	Communication	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	6	1
C15	Collaboration	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	8	2
C16	Transparency	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	6	1
C17	Learning organisation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21	9
C18	Information/knowledge sharing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21	9
C19	Joint knowledge creation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21	9
C20	Information technology	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21	9
C21	Knowledge storage	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21	9

Step 5: Build the ISM model

Based on the final reachability matrix, the structural model of the proposed model one can be generated. If there is a relationship between attributes *i* and *j*, then an arrow is drawn to connect the two points. The graph is named directed graph or digraph. After eliminating the transitivity, the digraph is then finally transformed into an ISM model (see Figure 1).

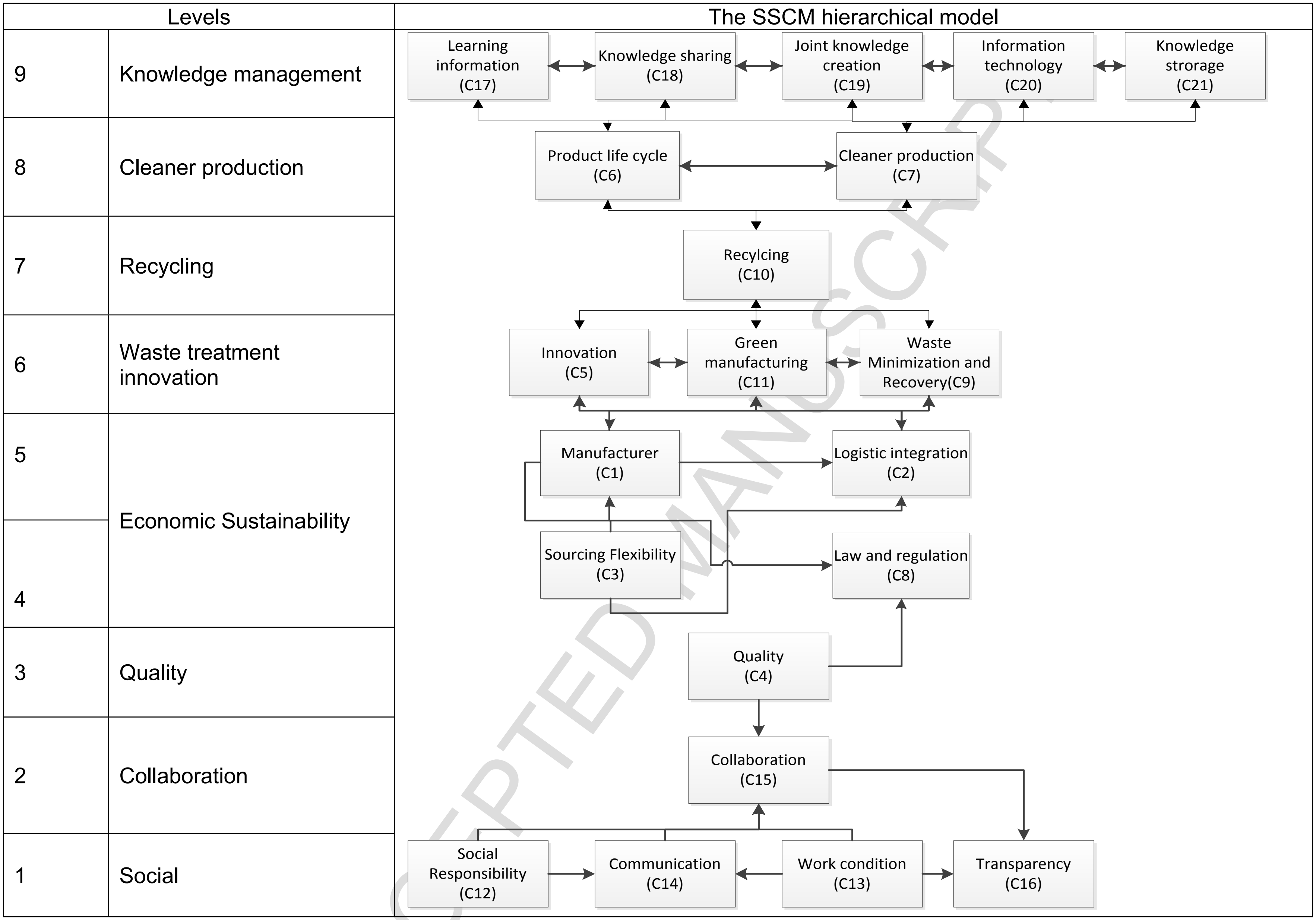

Figure 1: ISM-based model

The study of ISM to identify performance improvement criteria has provided some useful observations in relation to key attributes. It is essential for firms to obtain communication (C14) amongst their supply chain partners to establish basic foundation to achieve SSCM. Besides that, communication is also affected by, e.g. social responsibility (C12) and work condition (C13) which play an important role in improving communication with their partners. In addition, for firms of higher level for SSCM purpose is collaboration (C15) and this criterion is an outcome of the three criteria mentioned above where firms should consider in order to improve collaboration and quality (C3) of products which brings higher value for customer through cooperation firms and supply chain partner for sustainability in supply chain. Furthermore, collaboration (C15) and work condition (C13) has affected transparency (C16) of firms which aids to promote social performance and contributed to SSCM. Apart from the impact of quality on collaboration, it also has an effect on law and regulation (C8) because better quality of products means that firms compliance with the rule sets that force the manufacturers to internalise product externally and to convert an open-loop supply chain into a closed-loop that encourages recycling and reusing, as well as improving product design.

Likewise, manufacture (C1) affects law and regulation. Sourcing flexibility (C4) remains directly associated to both manufacture (C1) and logistic integration (C2) because it is the ready capability of the supply chain architecture to cope with changes and to realign the chain in response to market uncertainty and change. It is also noticeable that green manufacturing (C11), innovation (C5), waste minimisation and recovery (C9) and recycling (C10) have mutual impact on each other. Innovation relates to the development of new ideas and the introduction of administrative or organisational technological changes which help to reduce waste in manufacturing and keep materials in recycling process. For better products, product life cycle (C6) and cleaner production (C7) also have the same impact as the criteria mentioned above. From the product life cycle, firms can pinpoint the problems with the products and better understand the product features in order to improve the production in terms of both environmental issues and the ability of products, which helps to achieve SSCM. The final step is aggregating the knowledge of the steps above which is known management and consists of learning information (C17), knowledge sharing (C18), joint knowledge creation (C19), information technology (C20) and knowledge storage (C21). From that, firms are able to realise the approach to move towards SSCM.

Step 6: Construct driving and dependence power diagram

This sub-section is conducted to analyse driving and dependence power of the proposed criteria. The driving and dependence power diagram is constructed with the input from the total reachability matrix. In this diagram, the driving power is represented as horizontal axis and dependence power as vertical axis. The twenty-one criteria are then plotted on the diagram, as shown in Figure 2, to illustrate their association with the driving and dependence power.

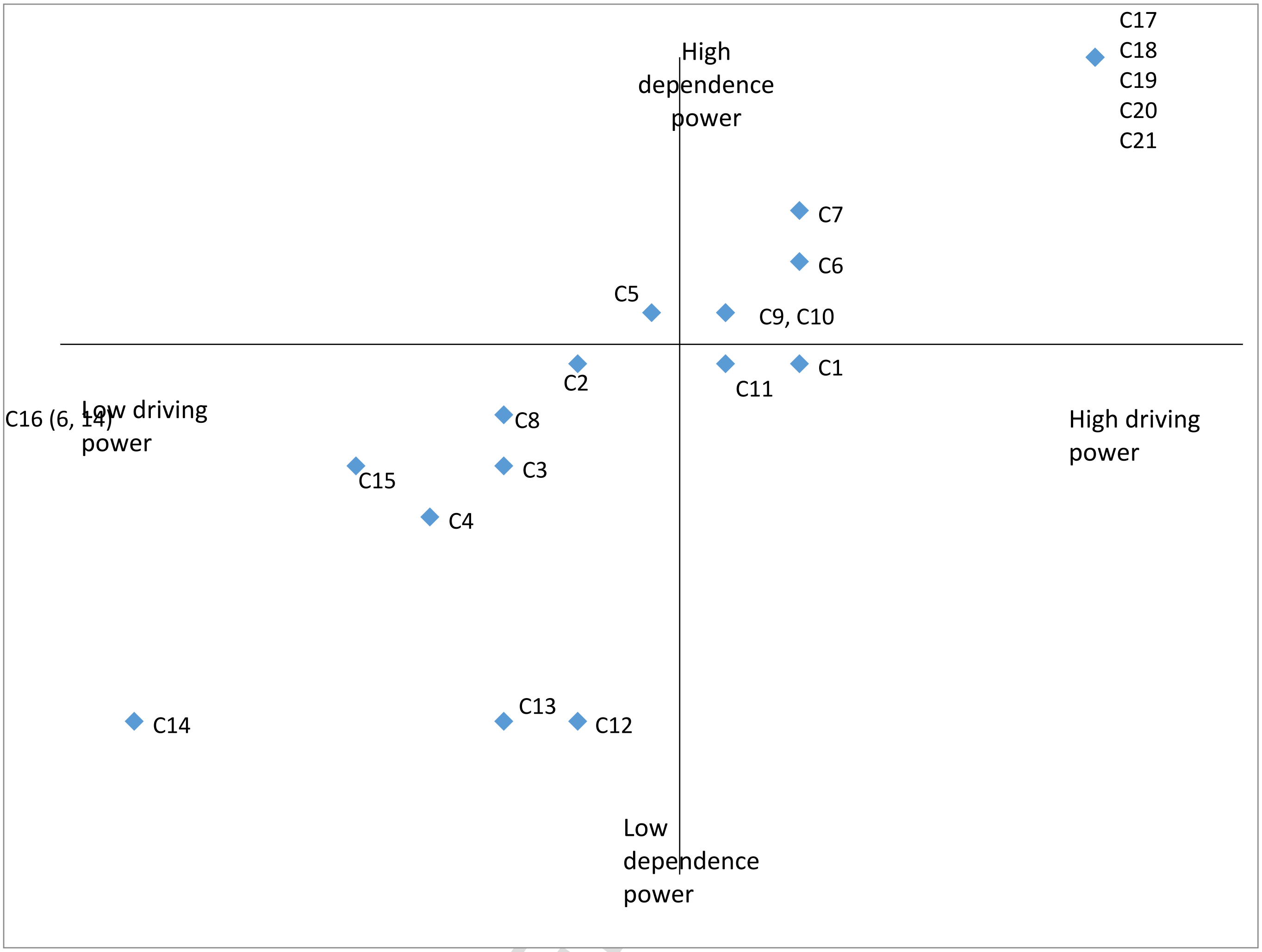

Figure 2: Dependence and driving power of SSCM's attributes

Figure 2 shows transparency (C16), collaboration (C15), quality (C4), sourcing flexibility (C3), law and regular (C8), work condition (C13), social responsibility (C12), logistic integration (C2) have low driving and low dependence power. These criteria are almost disconnected from the system. Those criteria which have low driving power and high dependence power include green purchasing (C11), manufacture (C1), learning organisation (C17), knowledge sharing (C18), joint knowledge creation (C19), information technology (C20). Knowledge storage (C21), waste minimisation and recovery (C9) and recycling (C10), product life cycle (C6) and cleaner production (C7) are considered top priority, which have strong driving power and strong dependence power. They are unstable, or in other words, if there are impacts on these criteria, there is an effect on others as well as themselves. Innovation (C5) has high driving power but low dependence power. Overall, this driving and dependence power diagram is able to reveal the strengths and weaknesses of the proposed criteria.

5 Implications

This section presents theoretical contributions related to SSCM and provides managerial implications for practical reference.

5.1. Theoretical implication

This study contributes to knowledge by exploring decisive attributes of KM, thereby gaining better insights for SSCM research. This paper provides evidence suggesting that KM (AS4) and environment (AS3) are the decisive attributes of SSCM. Therefore, these two attributes should be the priority premises for improving supply chain operations.

The result confirmed that KM is decisive attribute in SSCM and is progressively considered an important source of sustainable competitive advantage. KM leaders are assumed to be critical in dealing the firm's intellectual assets which have the best potential for competitiveness. KM comprises of procedures that encourage the application and improvement of hierarchical information, in order to create values and sustain competitive advantage. KM has been perceived as an imperative source of competitive advantage and value creation as a vital element for skills development and improvement, and for the most part, as a determinant component for firms with worldwide aspirations (King & Zeithalm, 2003). In addition, knowledge that organisations build up is a dynamic asset that should be greatly supported. Knowledge increases the competitiveness of a firm through its commitment, while KM generates quality and useful information to bring benefits to a range of business operations and activities.

On the other hand, environmental aspects turned out to be a progressively strategic consideration for firms of any size. It verified the necessity of environmental management elements in SSCM which could eventually become a standard to improve firm's performance (Eltayeb *et al.,* 2009). Furthermore, organisations are obliged to take environmental issues into account to strengthen their firms' image, alongside with the true intention to protect the environment (Tseng & Chiu, 2013; Lin, 2013). The ISM-based model has proposed that in environment, cleaner production is an important driving attribute in SSCM. It enhanced proficiency; lower costs; preservation of crude materials and vitality; enhanced consistence to market prerequisites; enhanced environment; better consistence with natural regulations; more durable workplace for workers and; better open picture of the firm (Halme *et al*., 2002). Besides, recycling is also considered the procedure of arranging, actualising and controlling the proficient, related data from the purpose of utilisation to the point of source with the end goal of recovering worth or appropriate transfer. Waste treatment innovation is always argued about the attributes to save the resources. Moreover, this waste treatment innovation would better notice as a problem of environmental cost around the world. Hence, environmental protection has led to the initiatives of eco-friendly sustainability of firms.

5.2. Managerial implication

This study includes a few implications for firms to improve performance within SSCM context. Although previous studies indicated some attributes in SSCM measurement, but they do not show clear influence in supply chain operations. Having said that, the attributes could no longer be relevant due to the dynamic changing business environment. From this study of the criteria related to SSCM, five of them have the most driving and dependence power, i.e. learning organisation (C17), Information/knowledge sharing (C18), joint knowledge creation (C19), information technology (C20), and knowledge storage (C21). In fact, these five criteria formed the important of basic attributes to build SSCM. Hence, to achieve better performance, these should be highly regarded as the focal point and applied in operational activities.

Learning organisation (C17) is a way to improve SSCM, which extends the resource and knowledge-based views to the resources of supply chain and leads to competitive advantage. In addition, it helps managers [in fact, any employee] to better understand the vision of the firm. It is not just about simply training individuals, but a culture of learning at each organisation level. Besides, learning organisation contributes creations through receiving the accumulating knowledge to obtain new ideas to enhance performance and more effective competitive advantage with rivals in the same as well as other industry. Especially for textile industry in this study, learning organisation is a noticeable useful tool. Therefore, firms can apply learning organisation culture as a strategic approach for the entire organisation and formed a strong foundation moving towards SSCM.

Knowledge sharing (C18) is vital for successful KM in organisations. To improve the performance of firms, managers should make use of knowledge sharing to speed up response time. If the information flows through the firm effectively, it will avoid the waste of times in searching the right person for the right information. Creativity and innovation are also playing an important role in this respect. More informed workforce increases social interaction which has a positive effect on creativity. Also, the decision making of firms becomes more accurate and effective for deployment through effective information stream. Moreover, personal development assessment in firms can also be facilitated when staff share knowledge openly, and the senior management is able to obtain a much better understanding of staff development and can act more quickly to motivate and build up productive staff, which will lead to overall performance improvement. Hence, it can be seen that effective knowledge sharing has a vast range of benefits for the firms.

Joint knowledge creation (C19) relates to the interaction between supply chain partners by creating and sharing information together to have a clear understanding about tendency of market for long-term development, as well as exchanging technology to create something new which is appropriate with market requirement. This type of collaboration formed an effective means of knowledge transfer and new technical skills across firms for appropriate response to market changes and customer needs. This could benefit firms in term of faster product output, reduction of production waste and logistical cost, increase of efficiency as well as maximising return on investments. Hence, textile industry firms are suggested to make efforts to encourage joint knowledge creation such as outsourcing agreements, product innovation, and cooperative study the manager should pay attention more about their supply chain partner and with their competitors to find potential supply chain partners or sustainability for business. This will be a means to bring a firm operating under SSCM.

The field of information technology (C20) covers the design, administration and support of computer and telecommunication systems. It can significantly enhance the firm's ability to capture, process, and sharing information across the supply chain for coordinating and creating synergy. For textile industry in this study, information technology is a helpful instrument to solve various industry-specific problems, in particular the fast-moving consumers demand and trends.

Therefore, firms should pay more attention in their information technology by investing more to warranty effective competiveness, e.g. upgrading new information system to ensure for effective information flow under dynamic environment. This is the key to achieve competitive advantage to compete business rivals.

Knowledge storage (C21) can be seen as part of information technology. Generally, it is electronic information portals that help to archive the knowledge of the organisation. Besides, it is also reliable basic data to make innovations for firms to improve firm performance and stay competitive. For certain case in textile industry in this study, knowledge storage would help firms to have valuable ideas to enhance performance in various terms such as productivity of production line for fast changing design, the intensity of employees in work, consuming energy to operate facilities to server for manufacturing products. Therefore, firms should put more consideration in knowledge storage to enhance its capability, in particular, establishing values to achieve SSCM.

6. Conclusion

SSCM and KM are two main streams of study in recent years. However, very few works have dealt with the link between these two topics (Samuel *et al.,* 2011). To address this gap, this study applied ISM technique to, firstly, attempt to identify the criteria of KM in SSCM. From the experts' opinions, there are four aspects: social, environment, economy and KM were proposed in 21 criteria, and secondly, explore the driving and dependence power of these attributes to improve the firm performance to achieve SSCM. The interrelationships amongst specific attributes were established to define a problem or an issue by means of their dependence and driving power (Mangla *et al.,* 2014). Thirdly, the action plans also were executed for the next frontier by providing extend experiential concept of KM in SSCM with a broader perspective of the measured level of the existing criteria. Hence, the extant literatures on SSCM were also highlighted for better performance.

From the hierarchical structural model, this study reveals that 21 criteria were divided into nine levels based on their driving and dependence powers. KM and environment are indicated as the decisive aspects of SSCM. KM can directly drive the environmental criteria, hence control firm's economic and social activities to improve firms' performance. In detail, this study segregated the proposed attributes into 9 levels, namely knowledge management, cleaner production, recycling, waste treatment innovation, economy sustainability (include level 4 and 5), quality, collaboration and social. The top five driving and dependence power criteria which include learning organisation, knowledge sharing, joint knowledge creation, information technology and knowledge storage are evidenced to have the strongest and the most significant impact on the system of SSCM in textile industry. These criteria play a role as bridging mechanisms in improving performance toward SSCM. Hence, they should be considered as the main criteria that can help firms to achieve a higher performance. Moreover, from the environments perspective, product life cycle, cleaner production, recycling and waste minimisation are also stated to be the critical criteria for practising SSCM.

The contribution of this study identifies the interrelationship amongst attributes, thereby, exploring the position of KM in SSCM. It has made a clear concept for this issue. KM was found to have the most potential role in enhancing SSCM with the construct of levels that were established in this study. In other words, managing knowledge in an integral and progressive way is a fundamental attribute to achieve sustainability in supply chain management. It has direct driving effect on the cleaner production and product life cycle, as well as receives the reverse effect from other attributes. However, the marketplace is becoming more and more globalised and competitive, as a result, competition is getting tougher and tougher. Therefore, controlling the KM attributes is very important to maintain supply chain sustainability. The efforts made to manage and improve effectiveness and efficiency of the supply chain are critical in order to remain sustainable competitive advantage. As a result, the action plan for the industry also has been developed to help firms compete with their rivals in the international market. By focusing on KM attributes, managers could have better decision making to attain SSCM. Overall, the insights gained from this study can provide a reference from which future empirical study can be based upon.

This study carries some limitations. Firstly, this study was conducted using relevant attributes from the literature, thus, the set of aspects and criteria might not be fully comprehensive. Secondly, this study adopted ISM methodology to evaluate the criteria. Although it is more accurate with the experts' practical experience and knowledge to decompose a complicated system into a number of attributes and to construct a multi-level structural model (Mathiyazhagan *et al.,* 2013), still, there are some disadvantages need to be considered: (1) the contextual relationship between the attributes is always depending on the user's knowledge and familiarity with the firm, and its operations and the industry it belongs to; (2) the bias of the judgment influence the final result; (3) ISM would drive the order and direction of the complexity of interrelationships; and finally, (4) there is no weight associated with the attributes (Ravi *et al.,* 2005). Hence, future study may employ other techniques to evaluate KM in SSCM. Thirdly, there is only description for the underlying routines of the sustainable textile industry, other industries have not been yet investigating. Future work will be necessary to study on other industry, which could give more insights or different dimension of understanding. Furthermore, the weight of the levels that named in this study could also be further studied and explored. Such a detailed description of KM in SSCM is still scarce, future study can focus on specific criteria to enrich the literature.

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Highlights:

- This research proposes a set of measures and interpretive structural modelling methods to identify the driving and dependence powers in sustainable supply chain management within the context of knowledge management in order to improve the performance of firms
- With the context of the textile industry in Vietnam, the research result indicated that learning organisation, information/knowledge sharing, joint knowledge creation, information technology and knowledge storage are amongst the highest driving and dependence powers.
- The contribution of this study identifies the interrelationship amongst attributes, thereby, exploring the position of knowledge management in sustainable supply chain management and the discussion of theoretical and managerial implications provided will be particularly useful for academics and practitioners.