Classification of the critical success factors in sustainable supply chain management using interpretive structural modelling

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Abstract: Due to the negative effects of the current way of life and industry on mankind's future, sustainable development has become one of the main factors in organisation's success. One of the strategies to achieve sustainable development is sustaining the supply chain of the organisation and industries. Identification of critical success factors is essential for any organisation in order to achieve the organisation's goals and missions. This study tried to identify critical success factors of sustainable supply chain to prioritise and determine the level of each factor. Success factors were extracted using literature review and experts' opinion. Then, the interpretive structural modelling was used to determine relationships and levels of each factor. 'Cultural and language differences' was identified as the most influential factor and 'information and transparency' was identified as the most impressionable factor in sustaining the supply chains. In addition, the results indicate a relatively strong relationship between identified factors.

Keywords: supply chain management; SCM; sustainability; critical success factors; CSFs; interpretive structural modelling; ISM.

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1 Introduction

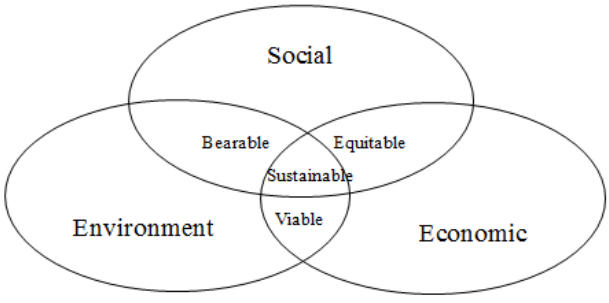
Many scientists believe that in today's competitive world, companies should concentrate on their supply chains (Safari and Mohebbimanesh, 2011). A supply chain structure is considered as a combination of potential suppliers, manufactures, distributors, retailers and customers that its main focus is on improving serving to customers, profitability and better performance in business (Cousins and Menguc, 2006). Supply chain approach derives from the fact that there are some dependence between different levels, from primary source to final user (Lambert et al., 1998). In the supply chain management (SCM) approach, there is an emphasis on the overall optimisation, not on the local optimisation or a specific unit. To this end and to enhance the performance in supply chain and quick response in turbulent business environment, companies have to change their attitude about suppliers, from enemy to partner and consider them as a source (Chang and Cheng, 2010).

In other words, competition in business in today's world is dependent on sustainable management (Gomes et al., 2014). Researchers believe that the importance of sustainable development is rising and it has become one of the focal points in governing the countries (Huang et al., 2013). According to the definition of sustainability which was presented in the report of the World Commission on Environment and Development in 1987, sustainability is a development that satisfies the present generation needs without limiting the ability of future generations in development of their needs (WCED, 1987). So we can say sustainability is decreasing of business harmful effects on people, communities and the environment at the same time with increasing value for customers, partners and shareholders (Schmidt, 1997). The main reason of increasing attention to sustainable development policy is limited possibilities and unlimited needs and demands of humankind. The world's resources are consumed rapidly while next generation cannot simply achieve to these resources. Hence, sustainability in resources has become one of the challenges of the world (Kavacik et al., 2012). Sustainable development is a challenge that today companies have to focus on it, because it has significant effects on their strategies (Fülöp and Hernádi, 2013). Researchers believe that to gain competitive advantage, it is necessary to use all the available opportunities in the field of sustainability (Jenkins, 2009). Sustainable development approach is primarily concentrate on changes in thoughts, beliefs and values. Everyone should understand that sustainability is about both global and local issues (Goedknegt and Silvius, 2012). The benefits of implementing sustainability in organisations is to reduce costs, increase productivity, reduce risk, improve reputation and brand value, higher sale, increase innovation opportunities, reduce adverse environment effects and great accountabilities to stakeholders (Conway, 2014).

In 90s decade the term and concept of 3P was proposed and it was pointed out that the sustainability is a balance or coordination between economic, social and environmental sustainability. This concept has been introduced as 'triple bottom lines'

and it offers a wide range of ideas and values for measuring the success of an organisation in the field of economy, society and environment (Silvius et al., 2012). The interaction between these three aspects is shown in Figure 1.

Figure 1 Triple bottom lines of sustainability



Source: Silvius et al. (2012)

Therefore, in the new economic field, long term success of any organisation is not only based on the profit, but its contribution to the future of the people and the earth is considered (Barbosa-Póvoa, 2009). Because objects in supply chain are considered from initial processing of raw materials to final delivery to the customer, focusing on supply chain is a step toward the acceptance and wider development of sustainability (Barbosa-Póvoa, 2009). Since supply chain managers are employed in all aspects of business including logistics, strategic planning, information services, marketing and sales and financials, each manager has an ideal position to do initiatives for sustainability (Sarkis, 1998).

While sustainable supply chain tries to integrate the goals of three dimensions of sustainable development (economic, environment and social), which is derived from the needs of customers and stakeholders, it considers material, information and capital management as well as cooperation between companies throughout the supply chain. Members of sustainable supply chain try to use social and environmental criteria to stay in the supply chain. At the same time, it is expected to maintain the competitiveness by responding to customer needs and related criteria (Seuring and Müller, 2008). Due to the pressure from the law, communities, shareholders and competitors in many countries, suitable choice which is compatible with sustainable activities in supply chain is one of the biggest challenges for the industries for moving towards a sustainable SCM (Luthra et al., 2014). External pressures on a company lead to sustainable supply and production, if both individual companies and entire supply chain be considered as an integrated entity and develop prerequisite for the implementation of sustainable SCM (Bowen et al., 2001). Sustainable SCM, which has already been implemented in developed societies, is still relatively a new subject in developing countries and it is in the early stages of adoption (Mangla et al., 2014). Therefore, establishing an affordable and environmentally friendly supply chain is considerable of the scientific and managing point of view. So, identification of critical success factors (CSFs) is required for implementation of SCM in a sustainable way, with an economical and effective method (Luthra et al., 2015).

CSFs are characteristics, conditions or variables that can have a significant effect on the success of an organisation in a specific area, if properly used and managed (Korpela and Tuominen, 1996). CSFs determine key areas of performance that is necessary to fulfil the mission of the organisation. Managers generally know and consider these critical factors in determining the goals. Specifying these factors makes a general reference point for the whole organisation. So the organisation must always ensure high performance of any action or innovation, in these critical areas. Otherwise the organisation may not be able to achieve its objectives and therefore fails to fulfil its mission (Caralli et al., 2004). Many experts believe that companies could identify the CSFs and gain good results in them for creation competitive advantage. Thus, having a distinctive position in some of the CSFs compared with other competitors makes a golden and unique opportunity for a company in order to gain competitive advantage (Zandiyeh, 2001).

Certainly, some of the CSFs are more important than others. Comparing these factors, choosing the best ones and prioritising them can help managers to make transparent decisions. So in this study, identification of CSFs of sustainable SCM and classification them using interpretive structural modelling have been considered. For this aim, CSFs of SSCM have been recognised using the literature review and experts' opinions. Then, the relationships among factors were examined by expert's consultation and the levels of factors were determined whit the help of ISM method.

2 Literature review

Sigala (2008) identified the CSFs of SSCM in tourism industry and recognised five general factors. These factors include sustainable product design, sustainable procurement, sustainable production, sustainable delivery-distribution and sustainable reverse logistics. Flores et al. (2008) surveyed the CSFs and challenges of sustainable supply chain development in India. In this study three sustainability dimensions were considered, but the results are useable in the special situation of India. Hu and Hsu (2010) identified the CSFs of green supply chain management (GSCM) in Taiwan's electrical and electronics industries. In this study, 20 factors in four categories were recognised and factor analysis (Bartlett) was used to determine the final factors. The four main categories are: supplier management, product recycling, organisation involvement and life cycle management. Kim and Rhee (2012) identified CSFs and examined their effects on the balanced scorecard (BSC) performance, in Korean's GSCM. Structural equation modelling (SEM) was used to examine the relationships. Relationship of SCFs and BSC was evaluated of both financial and non-financial performance. Toke (2012) began to recognise CSFs of GSCM in order to determine and select appropriate strategy to implement GSCM in the manufacturing industry in India. In this study 15 success factors and 19 performance measuring factors were identified. Then AHP method used to determine the relative importance of factors and select the appropriate approach. Top management commitment has gained the highest importance weight and social concern is in the second place of importance. Mishra et al. (2012) applied ISM to find the interrelationship of drivers of agile manufacturing. They identified the key drivers for implementation of agile concept in manufacturing in Indian environment. Kumar and

Banerjee (2012) investigated effect of collaborative culture on all collaborative activities in a supply chain using partial least squares. Results revealed that collaborative culture strongly affects all activities and also operation related activities were recognised as important factors enhancing performance. Debata et al. (2012) used ISM method to identify the interrelationship between medical tourism design requirements for evaluation of the medical tourism service providers in India. Ten dimensions of perceived medical tourism service quality were identified and were considered as voice of customers (VoC) and 11 design requirements were treated as design requirement for applying quality function deployment (QFD) in order to prioritise the design requirements. Mathiyazhagan et al. (2013) used ISM to analyse barriers in implementing GSCM. This study aimed to recognise the most dominant and influential barriers to the adoption and implementation of GSCM in the auto component manufacturing industries in India. In this study, 26 barriers were identified by reviewing previous researches, then; ISM was applied to determine the mutual influence amongst barriers. Finally, factors were classified in three groups of Independent, dependent and linkage by MICMAC analysis. Ab Talib and Muniandy (2013) by identifying the CSFs of SSM provided a conceptual framework to apply in Malaysia's transport companies. In this study CSFs of SSM were identified, by review the previous researches. Then this factors and success factors of green supply chain were integrated and four final factors were obtained. These factors consist of: information technology/system, human resource management/knowledge, collaboration and integration and government support. Ketikidis et al. (2013) evaluated the relationship between GSCM practices, pressures and environmental performance in Kosovo's construction industry using regression analysis. The findings indicated that GSCM practices and pressures significantly predicted the GSCM performance and Environmental performance is predicted GSCM practices and regulatory pressures of Kosovo construction companies. Malviya and Kant (2014) discussed cause and effect relationship between the influential factors and identified the CSFs for implementation of GSCM in Indian automobile industry. So, 12 influencing factors were found through reviewing the previous researches. Then, CSFs were extracted using fuzzy DEMATEL method. These factors are five: top management commitment and support, strategic planning, environmental policy, willingness towards investment and employee empowerment and motivation. Grimm et al. (2014) focused on the food industry to identify critical factors which overcome the complexities and unique challenges of sub-supplier management. In this study, 14 CSFs were identified in the form of internal critical factors and external critical factors. This research focused on two food supply chains, each includes a business centre, a direct supplier and a sub-supplier. Then unique CSFs for management of sub-suppliers were identified, to ensure their compliance with corporate sustainability standards (CSS) in food supply chains and presented as 14 factors. Chand et al. (2014) identified ten operational risk factors in supply chain and used weighted interpretive structural modelling (W-ISM) approach to develop a structural modelling between these factors. Then a method of effectiveness index (EI) was applied to identify the key areas. Satapathy (2014) used ANN to test the service satisfaction in electricity service in India and designed a frame work by QFD. In this study ISM was applied to find interrelationship between design requirements. Luthra et al. (2015) recognised CSFs to implement GSCM towards sustainability in mining industry in Indian perspective.

Table 1 Summary of literature review

Researchers	*Survey items*	*Methodology*	*Focus/scope*
Sigala (2008)	Identification of CSFs	Model development	SSCM
Flores et al. (2008)	Identification of CSFs and challenges		SSCM
Hu and Hsu (2010)	Identification of CSFs	Factor analysis	GSCM
Kim and Rhee (2012)	Identification of CSFs and their effects on BSC performance	SEM	GSCM
Toke (2012)	Identification of CSFs	AHP and statistical analysis	GSCM
Mishra et al. (2012)	Identification of key drivers	ISM	Agile manufacturing
Kumar and Banerjee (2012)	Identification of culture and activities	Partial least squares	SCM
Debata et al. (2012)	Identification of design requirements	ISM and QFD	Medical tourism
Mathiyazhagan et al. (2013)	Identification of barriers	ISM و MICMAC	GSCM
Ab Talib and Muniandy (2013)	Identification of CSFs	Present a conceptual framework	GSCM
Ketikidis et al (2013)	Identification of practices, pressures and environmental performance	Regression analysis	GSCM
Malviya and Kant (2014)	Identification of CSFs	Fuzzy DEMATEL	GSCM
Chand et al. (2014)	Identification of operational risk factors	W-ISM and EI	SCM
Satapathy (2014)	Identification of design requirements	ANN, QFD and ISM	Electricity service
Grimm et al. (2015)	Identification and classification of CSFs		SSCM
Luthra et al. (2015)	Identification of CSFs and their relationships	ISM and MICMAC	GSCM
Gandhi et al. (2015)	Identification of influential factors	DEMATEL	GSCM
Hussain et al. (2016b)	Identification of indicators	Present a conceptual framework	SSCM
Hussain et al. (2016a)	Identification of alternatives	ISM and ANP	SSCM
Mangla et al. (2016)	Identification of CSFs	AHP و DEMATEL	Reverse logistics

In this study, 26 CSFs of sustainability identified based on previous studies and experts' opinion. Next, the relationship between them found out using ISM method and a hierarchy structural model was proposed. Gandhi et al. (2015) evaluated the factors associated with successful implementation of GSCM. In this study, 15 factors of GSCM were extracted using literature review and they were analysed by DEMATEL. Research

result shows that top management commitment, human technical expertise and financial factors have the highest influence power on acceptance and successful implementation of GSCM. Hussain et al. (2016b) provided a framework to develop and assess the sustainability in supply chain of service industry. In this framework, 4 indicators of environmental management, social responsibility, health, safety and risk management, customer management and 18 sub criteria was considered. The results show that all 4 variables have strongly positive correlation with each other and the most correlation is between social responsibility and health, safety and risk management. Hussain et al. (2016a) in their study evaluated alternatives for SSCM. They proposed an integrated framework based on ISM and ANP methods. To evaluate the enablers of sustainable development, the criteria considered in three dimensions of economic, environmental and social. The results reveal that governmental regulations, rewards and incentives and listening to views of the customers are the main enablers for achieving sustainability in supply chains. Mangla et al. (2016) identified and evaluated the CSFs of reverse logistics in manufacturing industry of India. In this study, AHP method was used to prioritise of the factors and DEMATEL approach was used to categorise the relations among them. Findings show that global competitiveness factor get the highest rank in acceptance of reverse logistic.

3 Methodology

The aim of this research is to identify the CSFs of sustainable SCM and classify them based on their contextual relationships. Data were collected using literature review, questionnaire and experts' opinion. Identification of CSFs was done by searching for related studies and reviewing the literature. For recognition of the most important CSFs and determining the contextual relations among them a questionnaire was developed. Research statistical population was university teachers who were specialist in the both supply chain and sustainability management. Factors level was determined through ISM method after the identification of CSFs. Figure 2 shows the methodology followed in this study. This methodology and the results are discussed in the following sections.

3.1 Step 1: theoretical studies and identification of the SCFs of sustainable supply chain

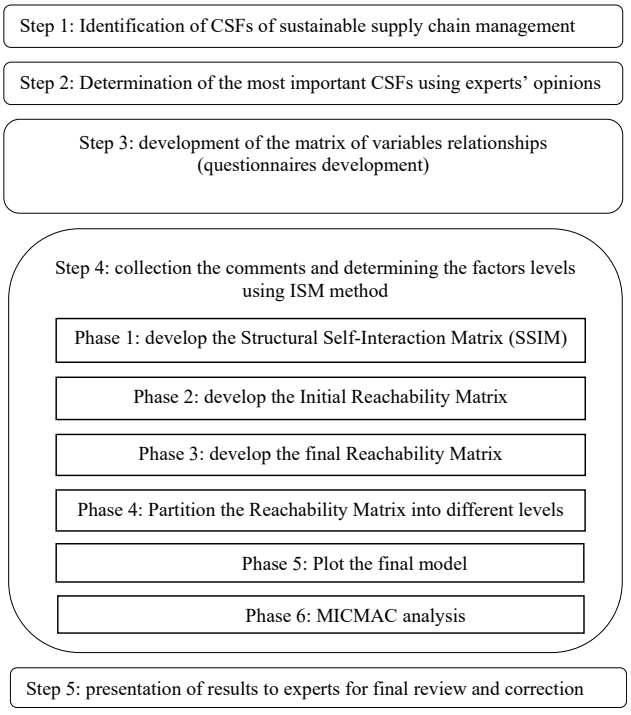
In the first step, CSFs of sustainable supply chain were extracted based on literature review and previous researches in three dimensions of sustainability including: environmental, social and economic sustainability. By omitting overlaps, identified factors were 67 which were used as the base information in the research.

3.2 Step 2: determination of the most important CSFs based on experts discussions

In order to identify the most important CSFs of sustainable supply chain and to reduce the number of factors, the identified factors list was given to university teachers and experts who were specialist in both SCM and sustainability field. Proposed factors in Grimm et al. (2014) research were recognised as the major factors based on experts'

opinions. The mentioned research is the only found research which considered all three dimensions of sustainability (economic, social and environmental sustainability) to identification of CSFs of supply chain. In the other hand, the identified factors of this study are in common with the identified factors of other studies. Although, this research focused on supplier in sustainable supply chain, its proposed factors overlapped the factors of other studies as well. Final factors list is given in Table 2 and their descriptions are presented after the table.

Figure 2 Flow chart of the research methodology



1 Costs and financial resources: high costs of management of sustainable supply chain and the limitation of financial resources of organisations.

2 Willingness towards investment: Tendency to investment in order to sustainability goals.

3 Competences and skills: personnel's skills and abilities in sustainability field.

4 Personnel commitment: personnel's commitment and responsibility for sustainability and cooperation in this field without the presence of a supervisor.

5 Trainings: promotion of knowledge, skills and abilities of suppliers and employees about sustainability.

6 Top management commitment and support: top management's valid understanding of sustainability and its importance in supply chain; commitment, support and management of attempts in sustainability field.

7 Power over independent suppliers: organisation power over supply chain partners in order to adapt them to organisation sustainability standards and provoke responsible behaviours in this area.

8 Stakeholder partnerships, (e.g., suppliers, sellers, industry fellows and non-governmental organisations): omitting obstacles and difficulties of sustainability with cooperation with stakeholders including suppliers, sellers, non-governmental organisations and industry fellows.

9 Stakeholder pressures, (e.g., non-governmental organisations, suppliers and customer's demands): developing advertising campaigns by NGO's to produce more sustainable products; customer's attention to health, security and environment; and buying sustainable products by customers.

10 Commitment and trust between supply chain partners: trust the partner abilities in implementation of sustainability; mutual benefits based on agreement; acceptance of the same performance criteria for sustainable products.

11 Supplier competences: supplier's competences based on sustainability principles.

12 Information and transparency: have information and transparency about partners of supply chain and their processes and policies.

13 Cultural and language differences along the supply chain: differences in culture and Language among partners of supply chain.

14 Geographical distance along the supply chain: Geographical distance among partners of supply chain.

3.3 Step 3: developing the questionnaire for assessing the relations of CSFs

Interpretive structural modelling (ISM) was used to identify the contextual relationship among the CSFs and classify them. To do this, a questionnaire was designed and given to university teachers and experts who were specialist in sustainability and supply chain. This questionnaire is a squared 14 * 14 matrix including CSFs of sustainable supply chain, in which relations of factors has been evaluated pairwise by experts. These relationships are of 'leads to' type which means that one variable leads to another. The definition of each identified SCF and the instruction of completing the questionnaire has been mentioned in the first part of the questionnaire. In the second part, relation matrix has been given to complete. In this questionnaire, the influence of each factor on other 13 factors has been questioned. Respondents were asked to check the pairwise relation between factors and complete it according to ISM method.

Validity concept used to ensure that the measures adequately quantify the concepts that they are supposed to test (Sekaran, 2003). The questionnaire validity used in this study was confirmed by experts' comments. To do this, the questionnaire was given to some academic experts in the field of sustainable supply chain, along with its objectives, in order to be logical and clear. They were asked to state their modification ideas about the questions. Feedbacks were used to improve the questions and eliminate redundancies that existed.

Reliability refers to the extent to which a measuring procedure (questionnaire/instrument) yields the same results on repeated trials (Carmines and Zeller, 1979). In fact it shows the consistency and logical coordination between items in each variable, during the survey period (Hair et al., 2006). Since in this study questionnaires were completed by experts, reliability test was not necessary.

Table 2 CSFs of sustainable SCM

Critical factors to SSCM		*Sources*						
		Grimm et al. (2015)	*Luthra et al. (2015)*	*Hu and Hsu (2010)*	*Kim and Rhee (2012)*	*Toke (2012)*	*Mahviya and Kant (2014)*	*Ab Talib and Muniandy (2013)*
1	Costs and financial resources	✓						
2	Willingness towards investment	✓					✓	
3	Competences and skills	✓	✓					✓
4	Personnel commitment	✓		✓	✓	✓		
5	Trainings	✓		✓	✓			
6	Top management commitment and support	✓	✓	✓		✓	✓	
7	Power over independent suppliers	✓						
8	Stakeholder partnerships	✓	✓					✓
9	Stakeholder pressures	✓	✓					
10	Commitment and trust between supply chain partners	✓			✓			
11	Supplier competences	✓						
12	Information and transparency	✓	✓		✓			✓
13	Cultural and language differences	✓						
14	Geographical distance	✓						

3.4 Step 4: comments collection and determining factors levels using ISM method

Structural self-interaction matrix (SSIM) in ISM model contains qualitative variables. So, mode (data frequency) is used to collect all opinions and take one response. Then, the matrix is converted to a binary matrix and compatibility is established in its relations. As

a result, final reachability matrix is obtained and the driver power and dependence power of each factor is determined. Then, by determining the antecedent and reachability sets, the variables were classified (Kannan et al., 2009). Moreover, MICMAC matrix is portrayed to identify the key CSFs that drive the system in various categories. Based on their drive power and dependence power, the CSFs, have been classified into four categories of: Independent, Dependent, Linkage and Autonomous variables.

3.5 Step 5: presenting the results to experts for reviewing and correction if it is necessary

Finally, to check for conceptual inconsistencies and make the necessary modifications, the results of levels partition and classification of the factors was given to experts.

3.6 ISM approach

Discovering the relations and dependencies between variables and ranking and determining the levels of them can help managers for better implementation of designed model, in models in which qualitative variables are at different levels of importance and have an effect on each other (Benítez and Fierro, 2011; Huang et al., 2005). ISM method is one of the ways that analyse the impact of an element on others and places variables in different levels. In this way, the complexity of the elements is overcome and mental and unclear models are transformed to visible and well-defined models (Sage, 1977). This method can classify the variables into 4 groups, based on their dependency and driving power. By identification of the variables discussed in the study, ISM will start. This can be done using previous studies and receiving experts' opinion.

In this study, ISM model variables are the CSFs which identified in step 2. The various steps involved in the ISM methodology are as follow (Kannan and Haq, 2007; Kannan et al., 2009):

3.6.1 Phase 1: develop a SSIM

In the first step, pairwise relationships among factors are checked by experts and based on contextual relationships among identified CSFs, a SSIM is developed. Relation between the variables (i and j) are determined with the following symbols:

- V: The variable in row (i) helps to achieve the variable in column (j)
- A: The variable in column (j) helps to achieve the variable in row (i)
- X: Variable in row (i) and column (j) help each other to be achieved
- O: Variable in row (i) and column (j) are unrelated.

The data are collected based on non-parametric methods and frequency. Structural-self interactive matrix is given in Table 3 which is gained by experts' opinion.

Table 3 SSIM of CSFs

CSFs		14 *Geographical distance*	13 *Cultural and language differences*	12 *Information and transparency*	11 *Supplier competences*	10 *Commitment and trust between supply chain*	9 *Stakeholder pressures*	8 *Stakeholder partnerships*	7 *Power over independent suppliers*	6 *Top management commitment and support*	5 *Trainings*	4 *Personnel commitment*	3 *Competences and skills*	2 *Willingness towards investment*
1	Costs and financial resources	A	A	O	O	X	A	A	A	V	A	A	A	O
2	Willingness towards investment	X	A	O	O	O	A	O	O	A	O	O	O	
3	Competences and skills	O	O	O	O	V	O	O	O	O	A	O		
4	Personnel commitment	O	O	O	O	X	O	O	O	A	A			
5	Trainings	O	O	O	V	V	O	O	O	X				
6	Top management commitment and support	O	O	O	O	V	A	O	O					
7	Power over independent suppliers	O	O	O	O	O	O	O						
8	Stakeholder partnerships	O	A	O	O	V	X							
9	Stakeholder pressures	O	O	V	O	O								
10	Commitment and trust between supply chain partners	O	A	V	O									
11	Supplier competences	O	O	V										
12	Information and transparency	O	O											
13	Cultural and language differences	O												
14	Geographical distance													

3.6.2 Phase 2: develop the initial reachability matrix

In the second step, initial reachability matrix is obtained by converting the SSIM to a binary matrix. It is done by transforming the symbols of X, O, V and A into binary digits, (i.e., ones or zeros) for each cell of SSIM. This transformation is done with the following rules:

- If the (i, j) entry in the SSIM is V, the (i, j) entry in the initial reachability matrix is set to 1 and the (j, i) entry is set to 0.
- If the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix is set to 0 and the (j, i) entry is set to 1.
- If the (i, j) entry in the SSIM is X, then the entries in both the cells (i, j) and (j, i) in the reachability matrix is set to 1.
- If the (i, j) entry in the SSIM is O, then the entries in both the cells (i, j) and (j, i) in the reachability matrix is set to 0.
- If i = j in SSIM, the (i, j) entry in the initial reachability matrix is set to 1.

Table 4 Final reachability matrix for the drivers of CSFs

CSFs		*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1	Costs and financial resources	1	1	1	1	1	1	0	0	0	1	1	1	0	1
2	Willingness towards investment	1	1	1	1	1	1	0	0	0	1	1	1	0	1
3	Competences and skills	1	1	1	1	1	1	0	0	0	1	1	1	0	1
4	Personnel commitment	1	1	1	1	1	1	0	0	0	1	1	1	0	1
5	Trainings	1	1	1	1	1	1	0	0	0	1	1	1	0	1
6	Top management commitment and support	1	1	1	1	1	1	0	0	0	1	1	1	0	1
7	Power over independent suppliers	1	1	1	1	1	1	1	0	0	1	1	1	0	1
8	Stakeholder partnerships	1	1	1	1	1	1	0	1	1	1	1	1	0	1
9	Stakeholder pressures	1	1	1	1	1	1	0	1	1	1	1	1	0	1
10	Commitment and trust between supply chain partners	1	1	1	1	1	1	0	0	0	1	1	1	0	1
11	Supplier competences	0	0	0	0	0	0	0	0	0	0	1	1	0	0
12	Information and transparency	0	0	0	0	0	0	0	0	0	0	0	1	0	0
13	Cultural and language differences	1	1	1	1	1	1	0	1	1	1	1	1	1	1
14	Geographical distance	1	1	1	1	1	1	0	0	0	1	1	1	0	1

Table 5 Level partitions for CSFs

CSFs		*Reachability set*	*Antecedent set*	*Intersection set*	*Level*
1	Costs and financial resources	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14	1, 2, 3, 4, 5, 6, 10, 11, 12, 14	1, 2, 3, 4, 5, 6, 10, 14	3
2	Willingness towards investment	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14	1, 2, 3, 4, 5, 6, 10, 11, 12, 14	1, 2, 3, 4, 5, 6, 10, 14	3
3	Competences and skills	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14	1, 2, 3, 4, 5, 6, 10, 11, 12, 14	1, 2, 3, 4, 5, 6, 10, 14	3
4	Personnel commitment	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14	1, 2, 3, 4, 5, 6, 10, 11, 12, 14	1, 2, 3, 4, 5, 6, 10, 14	3
5	Trainings	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14	1, 2, 3, 4, 5, 6, 10, 11, 12, 14	1, 2, 3, 4, 5, 6, 10, 14	3
6	Top management commitment and support	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14	1, 2, 3, 4, 5, 6, 10, 11, 12, 14	1, 2, 3, 4, 5, 6, 10, 14	3
7	Power over independent suppliers	7	1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 14	7	4
8	Stakeholder partnerships	8, 9, 13	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 14	8, 9	4
9	Stakeholder pressures	8, 9, 13	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 14	8, 9	4
10	Commitment and trust between supply chain partners	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14	1, 2, 3, 4, 5, 6, 10, 11, 12, 14	1, 2, 3, 4, 5, 6, 10, 14	3
11	Supplier competences	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14	11, 12	11	2
12	Information and transparency	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14	12	12	1
13	Cultural and language differences	13	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14	13	5
14	Geographical distance	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14	1, 2, 3, 4, 5, 6, 10, 11, 12, 14	1, 2, 3, 4, 5, 6, 10, 14	3

3.6.3 Phase 3: develop the final reachability matrix

The final reachability matrix is constructed from the initial reachability matrix taking into account the transitivity rule. So, by controlling secondary relations between variables, the internal consistency has to be established. It states that if a variable 'i' is related to 'j' and 'j' is related to 'k' then 'i' is necessarily related to 'k'. One way of compatibility the matrix is recompleting the questionnaires by experts, then compatibility will be checked and this operation will be continuing so that compatibility is gained. The other way is using mathematical regulations. This is done by Oyler theory, in which the initial reachability matrix is added to the identity matrix and is raised to the power of n as following formulas:

$$A + I \tag{1}$$

$$M = (A + I)^n \tag{2}$$

In above relations, 'A' stands for initial reachability matrix, 'I' stands for identity matrix and 'M' stands for final reachability matrix. This operation should be done based on Bowlin regulation which states:

$$1 \times 1 = 1, \quad 1 + 1 = 1 \tag{3}$$

The final reachability matrix for the CSFs is shown in Table 4.

3.6.4 Phase 4: partition the reachability matrix into different levels

At this stage, the reachability matrix obtained in Step 3 is partitioned into different levels. To do this, reachability and antecedent set for each variable must be extracted from the final reachability matrix. The reachability set for a particular variable consists of the variable itself and the other variables, which it may help achieve. So, related row is surveyed and the number of 1 in that row shows directional lines that are taken out of that part. The antecedent set consists of the variable itself and the other variables, which may help in achieving it. Therefore the number of 1 in related column show directional lines that enter to that part.

Subsequently, the intersection of these sets is derived for all variables. The variable for which the reachability and the intersection sets are the same is placed at the top-level of the ISM hierarchy. Then this variable is eliminated and the abovementioned procedure is repeated with other remaining variables as far as all variables levels are specified. In this study, CSFs were placed in 5 levels. It should be noted that the factors of level 5 have most influence on the factors of other levels and factors of level 1 have the greatest impressibility of others. Reachability, antecedent and intersection sets and levels are presented in Table 5.

Figure 3 ISM model for CSFs of SSCM

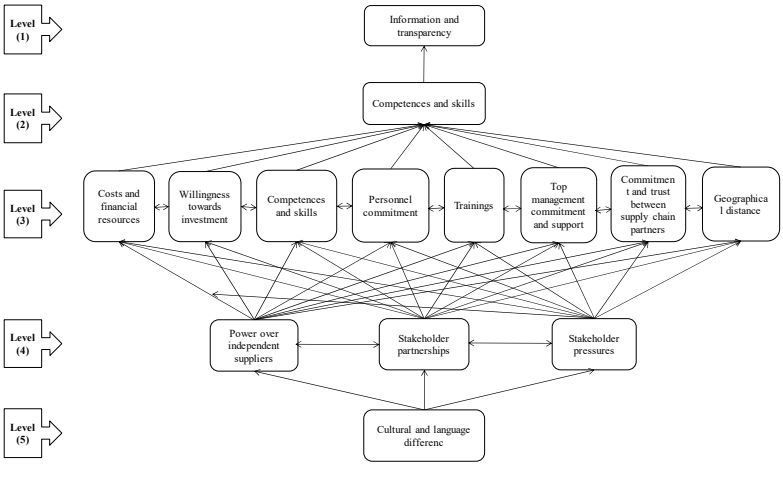
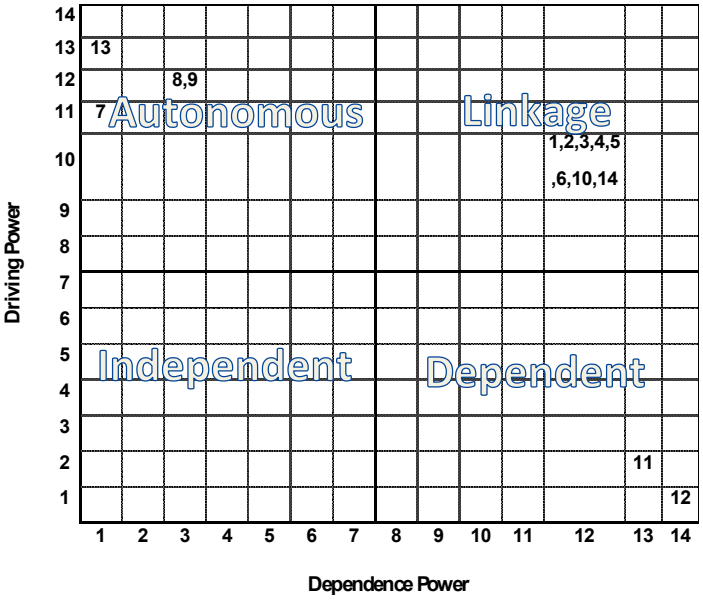


Figure 4 Driving power and dependence power diagram (see online version for colours)



3.6.5 Phase 5: portray the final interpretive structural model

In this step, based on the relationships given above in final reachability matrix and levels of variables, a primary model is drawn. By removing the transitive links final model is obtained. The CSFs model of sustainable supply chain is shown in Figure 2. Factors of 'information and transparency' and 'supplier competences' are placed at the first and second levels that show the dependency of these two factors on other factors and change in other factors can change these two factors. 'Cultural and language differences' which is at the fifth level acts like a cornerstone of the model. Developing a sustainable supply chain is better starts from this variable which resulted in sustainability of higher level factors. 'Power over independent suppliers', 'Stakeholder partnerships' and 'stakeholder pressures' are the factors that affect the other factors and they are impressed by 'cultural and language differences'. Moreover, these factors are in relation with each other. Organisations can strengthen other CSFs in order to manage sustainable supply chain with focus and improvement of these factors.

3.6.6 Phase 6: analysis of driving power and dependence power (MICMAC)

Finally, factors are classified into four categories based on drive power and dependence power of each factor, as well as determining the levels of factors by ISM method. Driver power is related to row sum and dependency power is related to column sum of indicators and according to it, driving power vs. dependence power diagram is plotted. Driving

power and dependence of factors are shown in Table 6 and MICMAC matrix is shown in Figure 3.

The results are as follow:

1 Autonomous variables: classification of CSFs of SSCM shows that there is no factor in this category with weak driving power and weak dependence power. This group shows the factors that are relatively disconnected from other factors and have few links. So, in CSFs set that identified in this study, there is no factor without any relation with others and this means that there is a strong relationship among factors in sustainability model.

2 Dependent variables: factors of 'supplier competences' and 'information and transparency' are in dependence area. These factors have weak driving power but strong dependence power. So, these factors are less able to underlie other factors but many factors are involved in the creation of these factors. To achieve these factors, we have to pay attention to the factors that are in linkage level.

3 Linkage variables: 'costs and financial resources', 'willingness towards investment', 'competences and skills', 'personnel commitment', 'training', 'top management commitment and support', 'commitment and trust between supply chain partners' and 'geographical distance' are placed in linkage area. These factors have both strong driving power and dependence and have a lot of influence on dependent factors. They have mutual relation with other factors so any change in them will affect the others and finally the system feedback can change these factors again.

4 Independent variables: 'cultural and language differences', 'power over independent suppliers', 'stakeholder partnerships' and 'stakeholder pressures' are in independent category with weak dependence power but strong driving power. These factors act like a cornerstone of the model and to start the function of the system, they must be emphasised at first. In fact, independent factors are key factors and can play a significant role in organisation success for the implementation of sustainable SCM.

Table 6 Driving power and dependence power of CSFs

CSFs	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
Driving power	10	10	10	10	10	10	11	12	12	10	2	1	13	10
Dependence	12	12	12	12	12	12	1	3	3	12	13	14	1	12

4 Conclusions

Nowadays, sustainable development has been turned to a global strategic aim in all parts. Now, sustainability is one of the most words used in different scientific, academic and industrial communities. In last decades many companies have been considered sustainability in their strategies. Sustainable development is seeking for maintaining, developing and balancing of social, economic and environmental resources and goals in order to prepare security, comfort and welfare of present and future generations. Researchers believe that the activities which are done base on sustainability can be assumed as critical factors for long term success of businesses.

To achieve sustainability it is necessary for organisations to pay attention to it in the phase of preparing materials and primary components which results in sustainable supply chain. SCM can be seen as a systematic approach for managing the information, materials and services from suppliers of raw material through factories and warehouses to customers and vice versa. Therefore, focusing on supply chain is a step toward acceptance and promotion of sustainability. Moreover, there are pressures for presenting report of sustainable performance to all beneficiaries, along with reporting the economic performance to shareholders. So, identification of CSFs of organisations is crucial in order to make and maintain a sustainable supply chain in different industries.

In this study, identification of CSFs in sustainable supply chain and evaluation their relations and determination the levels of them was done using ISM. Fourteen factors were identified, as the most important CSFs, by reviewing previous researches. Three dimensions of sustainability are considered in this study. Then, factor relation matrix was completed by academic experts and factors were placed in five levels based on their opinions and ISM analysis. According to conceptual model of CSFs of sustainable supply chain, 'language and cultural differences' factor is the base of the model and it has to be focused as the most important CSF of sustainable supply chain. 'Power over independent suppliers', 'stakeholder partnerships' and 'stakeholder pressures' are the factors that influence other factors and they have to be considered. Recent researches emphasise on pressure of government, customers and different groups of stakeholders as stimulus for the companies in order to use sustainability subjects in SCM (Bowen et al., 2001) which supported by the results of our study. Also, the results reveal that there is a strong relation between identified CSFs.

With the help of this study, there are instruments and techniques for managers of the companies and organisations to evaluate these factors in programming supply chain and choosing suppliers, with determining critical success indicators and criteria of each indicator. By focusing on factors identified as autonomous factors, companies can be more successful in sustaining their supply chain. Identified CSFs of sustainable SCM, can be used in all manufacturing and service organisations and companies. By identification and evaluation of these factors it is possible to move forward to increase sustainability of supply chain as a part of organisation competitive advantage.

4.1 Limitations and future scope

This study also has some limitations. First, the applied model is based on the ISM approach, which has its own limitations. The model is highly dependent on the judgments of the experts so, the experts' opinions may be biased. Furthermore, the results may be affected because of complexities of ISM method in evaluating the pairwise relationships of several numbers of items. Second, in the present paper, the identified CSFs of Grimm et al. (2014) which considered as the main factors may not be the best factors. Thus, it is suggested that in future researches apply different methods for classification of CSFs and compare the results with findings of this paper. Moreover, there is scope to use statistical tests, factor analysis or t test for selection of sustainable supply chain CSFs.

References

Ab Talib, M.S. and Muniandy, S. (2013) 'Green supply chain initiatives in Malaysia: a conceptual critical success factors framework', *World Applied Sciences Journal*, Vol. 26, No. 2, pp.276–281.

Barbosa-Póvoa, A.P. (2009) 'Sustainable supply chains: key challenges', *Computer Aided Chemical Engineering*, Vol. 27, pp.127–132.

Benítez, R.R. and Fierro, J.C. (2011) 'Reverse logistics practices in the Spanish SMEs context', *Journal of Operations and Supply Chain Management*, Vol. 4, No. 1, pp.84–93.

Bowen, F.E., Cousins, P.D., Lamming, R.C. and Farukt, A.C. (2001) 'The role of supply management capabilities in green supply', *Production and Operations Management*, Vol. 10, No. 2, pp.174–189.

Caralli, R.A., Stevens, J.F., Willke, B.J. and Wilson, W.R. (2004) *The Critical Success Factor Method: Establishing A Foundation for Enterprise Security Management*, DTIC Document, Software Engineering Institute.

Carmines, E. and Zeller, R. (1979) *Reliability and Validity Assessment, Series: Quantitative Applications in Social Science*, Sage Publications, Newbury Park, CA.

Chand, M., Raj, T. and Shankar, R. (2014) 'Analysing the operational risks in supply chain by using weighted interpretive structure modelling technique', *International Journal of Services and Operations Management*, Vol. 18, No. 4, pp.378–403.

Chang, K-H. and Cheng, C-H. (2010) 'A risk assessment methodology using intuitionistic fuzzy set in FMEA', *International Journal of Systems Science*, Vol. 41, No. 12, pp.1457–1471.

Conway, E. (2014) 'Assessing sustainability support to small and medium sized enterprises (SMEs)', *International Journal of Performability Engineering*, Vol. 10, No. 4, p.377.

Cousins, P.D. and Menguc, B. (2006) 'The implications of socialization and integration in supply chain management', *Journal of Operations Management*, Vol. 24, No. 5, pp.604–620.

Debata, B.R., Patnaik, B., Mahapatra, S. and Sreekumar (2012) 'An integrated approach for service quality improvement in medical tourism: an Indian perspective', *International Journal of Services and Operations Management*, Vol. 13, No. 1, pp.119–145.

Flores, M., Boer, C., Canetta, L., Pouly, M. and Cherian, M. (2008) 'Critical success factors and challenges to develop new sustainable supply chains in India based on Swiss experiences', Paper presented at the *Technology Management Conference (ICE)*, 23–28 June 2008, IEEE International.

Fülöp, G. and Hernádi, B.H. (2013) 'Sustainability accounting: a success factor in corporate sustainability strategy', *New Challenges of Economic and Business Development*, Vol. 4, No. 1, pp.1–12.

Gandhi, S., Mangla, S.K., Kumar, P. and Kumar, D. (2015) 'Evaluating factors in implementation of successful green supply chain management using DEMATEL: a case study', *International Strategic Management Review*, Vol. 3, No. 1, pp.96–109.

Goedknegt, D. and Silvius, A. (2012) 'The implementation of sustainability principles in project management', Paper presented at the *Proceedings of the 26th IPMA World Congress*, Crete.

Gomes, C.M., Kneipp, J.M., Kruglianskas, I., Da Rosa, L.A.B. and Bichueti, R.S. (2014) 'Management for sustainability in companies of the mining sector: an analysis of the main factors related with the business performance', *Journal of Cleaner Production*, Vol. 84, No. 1, pp.84–93.

Grimm, J.H., Hofstetter, J.S. and Sarkis, J. (2014) 'Critical factors for sub-supplier management: a sustainable food supply chains perspective', *International Journal of Production Economics*, Vol. 152, No. 1, pp.159–173.

Hair, Jr., J.F., Black, W.C., Babin, B.J., Anderson, R.E. and Tatham, R.L. (2006) *Multivariate Data Analysis*, 6th ed., Pearson Prentice Hall, Upper Saddle River, NJ.

Hu, A.H. and Hsu, C-W. (2010) 'Critical factors for implementing green supply chain management practice: an empirical study of electrical and electronics industries in Taiwan', *Management Research Review*, Vol. 33, No. 6, pp.586–608.

Huang, J-J., Tzeng, G-H. and Ong, C-S. (2005) 'Multidimensional data in multidimensional scaling using the analytic network process', *Pattern Recognition Letters*, Vol. 26, No. 6, pp.755–767.

Huang, W-C., Jhong, C-H. and Ding, J-F. (2013) 'Key factors influencing sustainable development of a green energy industry in Taiwan', *Mathematical Problems in Engineering*, No. 1, pp.1–10.

Hussain, M., Awasthi, A. and Tiwari, M.K. (2016a) 'Interpretive structural modeling-analytic network process integrated framework for evaluating sustainable supply chain management alternatives', *Applied Mathematical Modelling*, Vol. 40, No. 5, pp.3671–3687.

Hussain, M., Khan, M. and Al-Aomar, R. (2016b) 'A framework for supply chain sustainability in service industry with confirmatory factor analysis', *Renewable and Sustainable Energy Reviews*, Vol. 55, No. 1, pp.1301–1312.

Jenkins, H. (2009) 'A business opportunity' model of corporate social responsibility for small-and medium-sized enterprises', *Business Ethics: A European Review*, Vol. 18, No. 1, pp.21–36.

Kannan, G. and Haq, N.A. (2007) 'Analysis of interactions of criteria and sub-criteria for the selection of supplier in the built-in-order supply chain environment', *International Journal of Production Research*, Vol. 45, No. 17, pp.3831–3852.

Kannan, G., Pokharel, S. and Sasikumar, P. (2009) 'A hybrid approach using ISM and fuzzy TOPSIS for the selection of reverse logistics provider', *Resources, Conservation and Recycling*, Vol. 54, No. 1, pp.28–36.

Kavacik, M., Zafer, S., Yıldız, A. and Karaman, D. (2012) 'Sustainable development in aviation industry and the case of Turkish airlines', *Journal of Animal and Veterinary Advances*, Vol. 9, No. 3, pp.547–550.

Ketikidis, P.H., Hayes, O.P., Lazuras, L., Gunasekaran, A. and Koh, S.L. (2013) 'Environmental practices and performance and their relationships among Kosovo construction companies: a framework for analysis in transition economies', *International Journal of Services and Operations Management*, Vol. 14, No. 1, pp.115–130.

Kim, J. and Rhee, J. (2012) 'An empirical study on the impact of critical success factors on the balanced scorecard performance in Korean green supply chain management enterprises', *International Journal of Production Research*, Vol. 50, No. 9, pp.2465–2483.

Korpela, J. and Tuominen, M. (1996) 'Benchmarking logistics performance with an application of the analytic hierarchy process', *IEEE Transactions on Engineering Management*, Vol. 43, No. 3, pp.323–333.

Kumar, G. and Banerjee, R. (2012) 'An implementation strategy for collaboration in supply chain: an investigation and suggestions', *International Journal of Services and Operations Management*, Vol. 11, No. 4, pp.407–427.

Lambert, D.M., Cooper, M.C. and Pagh, J.D. (1998) 'Supply chain management: implementation issues and research opportunities', *The International Journal of Logistics Management*, Vol. 9, No. 2, pp.1–20.

Luthra, S., Garg, D. and Haleem, A. (2014) 'Critical success factors of green supply chain management for achieving sustainability in Indian automobile industry', *Production Planning and Control*, Vol. 26, No. 5, pp.339–362.

Luthra, S., Garg, D. and Haleem, A. (2015) 'An analysis of interactions among critical success factors to implement green supply chain management towards sustainability: an Indian perspective', *Resources Policy*, Vol. 6, No. 1, pp.37–50.

Malviya, R.K. and Kant, R. (2014) 'Identifying critical success factors for green supply chain management implementation using fuzzy DEMATEL method', Paper presented at the *Industrial Engineering and Engineering Management (IEEM), IEEE International Conference* on 9–12 December 2014.

Mangla, S., Kumar, P. and Barua, M.K. (2014) 'An evaluation of attribute for improving the green supply chain performance via DEMATEL method', *International Journal of Mechanical Engineering and Robotics Research*, Vol. 1, No. 1, pp.30–35.

Mangla, S.K., Govindan, K. and Luthra, S. (2016) 'Critical Success factors for reverse logistics in indian industries: a structural model', *Journal of Cleaner Production*, Vol. 129, No. 1, pp.608–621.

Mathiyazhagan, K., Govindan, K., NoorulHaq, A. and Geng, Y. (2013) 'An ISM approach for the barrier analysis in implementing green supply chain management', *Journal of Cleaner Production*, Vol. 47, No. 1, pp.283–297.

Mishra, S., Datta, S. and Mahapatra, S. (2012) 'Interrelationship of drivers for agile manufacturing: an Indian experience', *International Journal of Services and Operations Management*, Vol. 11, No. 1, pp.35–48.

Safari, H. and Mohebbimanesh, O. (2011) 'Proposing a conceptual model for supply chain quality management (SCQM) and surveying its position in Iran's car industry case study: IKCO Tondar 90 project', *Journal of Industrial Management*, Vol. 3, No. 7, pp.77–98.

Sage, A.P. (1977) *Interpretive Structural Modeling: Methodology for Large-Scale Systems*, McGraw-Hill, New York, NY.

Sarkis, J. (1998) 'Evaluating environmentally conscious business practices', *European Journal of Operational Research*, Vol. 107, No. 1, pp.159–174.

Satapathy, S. (2014) 'ANN, QFD and ISM approach for framing electricity utility service in India for consumer satisfaction', *International Journal of Services and Operations Management*, Vol. 18, No. 4, pp.404–428.

Schmidt, R. (1997) 'The implementation of simultaneous engineering in the stage of product concept development: A process orientated improvement of quality function deployment', *European Journal of Operational Research*, Vol. 100, No. 2, pp.293–314.

Sekaran, U. (2003) *Research Methods for Business: A Skill Building Approach*, Willey and Sons, Singapore.

Seuring, S. and Müller, M. (2008) 'From a literature review to a conceptual framework for sustainable supply chain management', *Journal of Cleaner Production*, Vol. 16, No. 15, pp.1699–1710.

Sigala, M. (2008) 'A supply chain management approach for investigating the role of tour operators on sustainable tourism: the case of TUI', *Journal of Cleaner Production*, Vol. 16, No. 15, pp.1589–1599.

Silvius, G., Brink, J.V.D. and Köhler, A. (2012) 'The impact of sustainability on project management', *The Project as a Social System: Asia-Pacific Perspectives on Project Management*, pp.183–200 [online] https://surfsharekit.nl/publiek/hu/1f55cb22-61d0-4b08-b7b1-1047ba09ec89.

Toke, L. (2012) 'An empirical study of green supply chain management in Indian perspective', *International Journal of Applied Science and Engineering Research*, Vol. 1, No. 2, pp.383–372.

World Commission on Environment and Development (WCED) (1987) *Our Common Future*, Oxford University Press, New York.

Zandiyeh, A. (2001) *Strategic Management Deployment*, Samt Press, Tehran.