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Abstract

Purpose – The modern business community understands the importance of long-term satisfaction of consumer. Enabling the consumer to return products is a significant part of the equation. The purpose of this paper is to analyze the sustainable boundaries in terms of their relationship toward greening a supply chain.

Design/methodology/approach – Using interpretive structural modeling the research presents a hierarchy-based model to realize the driving power and dependence of sustainable boundary enablers.

Findings – The research shows that there exists a group of enablers having a high driving power and low dependence requiring maximum attention and of strategic importance while another group consists of those variables which have high dependence and are the resultant actions.

Practical implications – This classification provides a useful tool to supply chain managers to differentiate between independent and dependent variables and their mutual relationships which would help them to focus while making strategic, tactical or operational decisions as and when required while designing a green supply chain.

Originality/value – This research assumes importance in context of greening a supply chain when globally enterprises are getting a lot of pressure from consumers as well as the regulatory measures from the government. Sustainability demands that the resources be used in lean manner through information coordination with all partners in a supply chain. The findings of this study would help delineate those variables that should to be necessarily considered to design a sustainable supply chain.

Keywords Innovation, Benchmarking, Interpretive structural modelling, Green supply chain management, Environmental sustainability, Reverse logistics, Strategic evaluation, Core competences, Closed-loop supply chain

Paper type Research paper

1. Introduction

In a world of finite resources and disposal capacities, recovery of used products and materials has become an endemic concern in industrialized countries. As a result, many countries have started to emphasize the prevention and control of pollution caused by discarded hazardous wastes. Regulations and laws are established to restrict and regulate the procedure for the return and recycle of these hazardous wastes. The European Union (EU) has established stricter codes for the handling of products containing hazardous substances, such as Directive 2002/96/EC related to

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"Waste Electrical and Electronic Equipment", Directive 2002/525/EC related to End of Life and the "Restriction of the use of certain Hazardous Substances in electrical and electronic equipment" regulations. To deal with this serious problem the Indian government has also taken many steps and has come up with innovative measures. The Ministry of Environment and Forests (MoEF) is the nodal agency for policy, planning and coordinating the environment programs, including electronic waste. The management of e-waste was covered under "management, handling and trans-boundary movement" rules 2007, part of EPA 1986 and Environment and Forests Hazardous Wastes Management Rules 2008. In May 2012, new rules are issued by the union MoEF to address the safe and environment friendly handling, transporting, storing, and recycling of e-waste. The concept of material cycles is gradually replacing a "one way" perception of economy. Increasingly, customers expect companies to minimize the environmental impact of their products and processes.

Take-back and recovery obligations have been enacted or are underway for a number of product categories including electronic equipment in the EU and in Japan, cars in the EU and in Taiwan, and packaging material in Germany. In this vein, the past two decade has witnessed an immense growth of product recovery activities. Some of the enterprises that are putting substantial efforts into remanufacturing used equipments include copy machine manufacturers Xerox and Canon. Xerox did resource recycling for collected products at 99.9 percent in 2011. They also reduced new resources use by 2,272 tons. The main drivers of this achievement are the increase in both products containing reused parts and the amount of resources recycled from consumable cartridges (Fuji Xerox, 2012, p. 23). Canon has been operating two remanufacturing factories for used copy machines in Virginia (USA) and in the UK since 1993 and is currently exploring comprehensive recycling systems for all copier parts. Toner cartridges have been collected for reuse since 1990 and have recycled around 287,000 tons of cartridges by the end of 2011 thereby saved around 430,000 of CO_2 (Canon Europe, 2011-2012, p. 5). Yet another example of product recovery concerns single-use cameras. Kodak started in 1990 to take back, reuse, and recycle its single-use cameras, which had originally been designed as disposables. Kodak is using 86 percent of reused parts in manufacturing their new cameras (David and Stewart, 2008). Some companies use remanufacturing of obsolete product components as the strategy for upgrading products (e.g. HP's main frame systems; Kupér, 2003 and Nortel's network systems; Linton and Johnston, 2000). Another group of companies recover the parts and components from used products to provide remanufactured replacement parts for customer service support, called cannibalization of components (e.g. IBM's computer service parts; Fleischmann *et al.*, 2004). Lastly, a number of companies collect their used products for material recovery to provide recycled materials to support their own operations or sell to other industries (Guide and Van Wassenhove, 2003), for example the plastic components recycling programs implemented by HP for printer cartridges and by Dell for computer peripherals.

Currently, in India, e-waste processing is being handled in two ways: formal and informal recycling. The Indian recycling industry recycles 19,000 million tons of e-waste every year. Of which, 95 percent electronic waste is recycled in the informal sector and only 5 percent goes for formal recycling. There is a very well-networked informal sector in the country (Sinha and Mahesh, 2007) involving key players like vendors, scrap dealers, dismantlers and recyclers. However, the disposal and recycling of computer specific e-waste in the informal sector are very rudimentary. The process followed by these recyclers is product reuse, refurbish, conventional disposal in landfills, open burning and backyard recycling. Of late, formal recycling is being pursued in a big way. Some initiatives have been taken to dismantle and dispose electronic items in the most environmentally sound manner; they also comply with occupational health and safety norms of the workers. Some major e-waste recycling companies are Trishyiraya (Chennai), Infotrek (Mumbai) and E-parisaraa (Bangalore).

1.1 Green supply chain management

Green or sustainable supply chain management is defined as the strategic, transparent, integration and achievement of an organization's social, environmental, and economic objectives in the systemic coordination of key inter-organizational business processes for improving the long-term performance of the firm and its supply chain partners (Ageron *et al.*, 2012). According to the moving direction, the supply chain can be divided into the forward and the reverse supply chain (FSC and RSC) (Fleischmann *et al.*, 1997). The FSC means acquiring the original material products from the suppliers and increasing their additional values by creating values in them through corporate managerial functions. On the contrary, the RSC process involves product return, source reduction, recycling, material substitution, item reuse, waste disposal, reprocessing, repairing and remanufacturing are all examples of recovery options that can represent an attractive business opportunity, a positive answer to sustainable development, and a way of achieving competitive advantage (Toffel, 2004; Srivastava, 2007; Jack *et al.*, 2010). Thus, environmental and social benefits decrease if FSC and RSC are not integrated into sustainable practices (Ageron *et al.*, 2012).

Research objective – supply chains consist of and span many boundaries. Typically, every boundary can be presented at many levels of analysis (Sarkis, 2012). Sarkis (2012) suggested nine forms of interrelated boundaries leading to GSCM. These boundaries include: organizational, informational, proximal, political, temporal, legal, cultural, economic and technological. Sarkis (2012) has elaborated these boundaries to a great extent. Our main objective in this paper is to determine the hierarchical contextual relationship between these boundaries. We therefore, in this paper, briefly delineate the idea of these boundary attributes from environmental sustainability perspective that academicians and practitioners have broadly illustrated in past. In other words, we have not confined ourselves to any specific level of boundaries mentioned by Sarkis (2012). In fact the level of boundaries is the outcome of the model proposed in this paper in Section 3 ahead. We consider these sustainability attributes as the enablers that help in realizing various practices toward fulfillment of greening of supply chain.

An organization comprises various sub-attributes that lead to greening the supply chain. The continuum of various sub-attributes of an organization ranges from scheduling on individual processing equipment to the relationships between different departments. All the activities at different levels of an organization intend to minimize the time and thereby reduction of energy wastage. Thus, the desired outcome for GSCM is the result of internal response practices adopted by an organization.

Lean practices are one of the ways of internal response to sustainability. Lean practices aims to minimize the waste. "Environmental wastes, including wasted energy, can cost companies thousands of dollars a year" – addressed by Chris Reed, a member of the United States Environmental Protection Agency's Lean and Environmental Initiatives. He further highlights that as public become more aware about the issues of climate changes, organizations are beginning to incorporate environmental concerns into their Lean activities. Chris Reed (2008) points out:

> […] A Lean event does not have to focus on environmental targets to achieve environmental benefits – often these come on the coattails of other activities. However, altering the scope of an activity to incorporate "green" aspects can have an exponential effect on both Environmental and Economic benefits.

Therefore, with lean practices (to save time), and thereby saving of energy at a very diminutive level of scheduling decisions, we can say:

> […] that Environmental sustainability accrues from exponential manifestation of a "Diminutive Activity" performed at operational level in an organization with coalition of supply chain network to environment.

The integration of FSC and RSC shows its potential benefit when timely (temporal boundary) communication (information boundary) are made between RSC and FSC. Information is not only critical for internal supply chain management operations, but can be a very effective regulatory tool that may cause organizations to re-evaluate their supply chain processes (Brown *et al.*, 2009). That is, environmental information flows may be used to provide certain public images of the supply chain and its members. Having this information made public can cause significant pressures from external stakeholders on the overall supply chain to improve environmental and social performance (Kovács, 2008). As the company reconfigure its processes based on gathered information, its market starts moving from local to other states or countries (expanding political, legal, and cultural boundaries). An important element of sustainability concepts is the new setup of actors, adding politics and regulations from the political arena to the traditional market schemes with companies and customers as actors. Due to this effect, many changes are enforced in companies and also in customer behavior recently unknown in standard rational market settings. The consumer has clearly expressed its concern about breaching the social rules concerning environmental obligations. This has created a pressure on business community as social ethics in a distant country may however substantially different. With these expectations, corporate social responsibility (CSR) plays a significant role. The EU green paper on CSR states: "Being socially responsible means not only fulfilling the applicable legal obligations, but also going beyond compliance […]". CSR concept includes not only behavior beyond the law but also the relevant legal obligations, primarily within the area of labor and environmental law. In such case, the CSR activities are of a mixed character, partly voluntary and partly mandatory. Thus we can say that law and CSR are interconnected and cannot be separated; in other words, the law influences voluntary CSR initiatives and vice versa. CSR is founded in both legal (mandatory) and ethical (voluntary) rules.

An organization's sustainability initiatives and its corporate strategy must be closely interlinked, rather than separate programs that are managed independently of one another (Shrivastava, 1995a). The organizations that become sustainable enterprises do not simply overlay sustainability initiatives with corporate strategies. These organizations also have (or have changed) their company cultures and mindsets (Savitz and Weber, 2006). Collins and Porras (1994) found that profit maximization was not the primary driving force of visionary organizations. Instead, these firms had core values and cultures and a sense of purpose beyond the economic bottom line. As additional support for the role of corporate culture in sustainability, Carter and Jennings (2004) found a significant relationship between environmentally and socially responsible purchasing activities and an organizational culture which considers the welfare of others and which is fair and supportive. The authors found interrelationships among risk management, transparency, culture, and strategy. The authors supported that all four of these are an integrated part of GSCM practices. For instance, engaging stakeholders, an example of improving transparency, can reduce risk by lowering the chances of consumer boycotts and targeted actions by non-governmental organizations, and can also be an explicit part of an organization's strategy. For example, at HP, stakeholder engagement is a key part of the development of HP's sustainability goals and strategy; HP's sustainability strategy is in turn used as one of the primary parts of its overall business strategy. Thus, the authors advocate that all four of these supporting facets are an integrated part of GSCM practices.

It is necessary to enable businesses to monitor and manage environmental aspects as an integrated perspective in their decision making and communication at all levels. What a company needs to measure and manage from an environment depends on the type of the company. Under the premise of technological boundaries, enterprise resource planning (ERP) is the natural place to handle environmental management functionality. ERP product with environmental footprint tracking tool already embedded in the package is the next level of technological sophistication. Embedding environmental measurement and management in ERP is most cost-effective and efficient since most of the data needed already exist and can be reused. An integrated, enterprise-wide approach handles environmental impact across the entire product lifecycle and the entire supply chain (Gunnarsson, 2011). The underline fact is that whether your green initiatives are focussed on green functional areas like supply chain network design, transport/logistics management, warehouse management; compliance areas like waste disposal/recycling/reuse; or energy natural resource consumption, explore the use of technology to provide the tools and visibility necessary to effectively identify and manage green practices.

The present research extends the knowledge of GSCM boundaries elaborated by Sarkis (2012) to a more comprehensible understanding by finding the hierarchy of interactions between the boundaries. We used interpretive structure modeling (ISM) technique to find the interactions between various GSCM enablers. For developing the structural self-interaction matrix (SSIM), we consulted five renowned researchers from top academic research institutes of India. Presently, these researchers are extensively engaged in the research of GSCM. With the consensus of these experts, we reached to final SSIM.

2. Literature review: evolution of green supply chain management

According to Merriam-Webster enabler is defined as "as one that enables another to achieve an end" where enable implies to make able; give power, means, competence, or ability to. Thus for the purpose of this research enabler is considered as a variable that enables (ability to) the attainment of sustainability in a supply chain. This definition is consistent with the use of the term enabler in ISM models like enablers of flexible manufacturing systems (Raj *et al.*, 2008), growth enablers in construction companies (Bhattacharya and Momaya, 2009), IT enablement in supply chain (Jharkharia and Shankar, 2004), enablers of reverse logistics (Ravi *et al.*, 2005), IT enablers for Indian manufacturing SMEs (Thakkar *et al.*, 2008), supply chain performance measurement system implementation (Charan *et al.*, 2008).

As GSCM grew and gained increased attention from researchers, the early literature in the area focussed on the significant impact of the approach on the well-being of the environments in which corporations work. Much of the work of early theorists focussed directly on the green approach as an economic plan for survival. Porter and Van Der Linde (1995a, b) discussed the rudiments behind the movement toward green practices, which were: increasing supply savings; reducing waste; and increasing productivity. According to Srivastava (2007), three advancements emerged in GSCM: the reactive, the proactive, and the value-seeking. Of these, the reactive approach requires the least supply investment, and usually involves updating product labeling and exploring ways to lower the impact of production on the environment. The proactive approach is a mid-level undertaking in which organizations invest modest capital in an attempt to self-regulate, and focus research and design on creating greener products while taking steps to create a recycling program. The last approach is value-seeking, through which companies focus on implementing ISO design and employing a green approach to purchasing. Hervani *et al.* (2005) argued that because of changing supply-chain requirements, environmental managers need to focus on a green approach in order to handle necessary supply-chain change. The product lifecycle has presented an increasingly important issue, especially when appropriation of material is involved, as well as the specific impact on product supplier relations in selecting materials for product development (Stonebraker and Liao, 2006). Several alternative methods exist to address the need for reverse logistics (Ravi *et al.*, 2005). Those methods foster guidelines, according to Mukhopadhyay and Setoputro (2005), which focus on return procedures of manufacturers when ordering merchandise. Kuo (2011) analyzed a supply chain model for manufacturing/remanufacturing scenario. The author analyzed different inventory management policies using discrete event simulation and suggested to investigate decision rules in case of remanufacturing. Akçali and Çetinkaya (2011) classified the structural framework at single echelon (manufacturing/remanufacturing) for the inventory and production planning models in closed-loop supply chain. Hong *et al.* (2012) suggest that the firms first strive for responsiveness to improve environmental performance. Second, lean practices are the important mediator to achieve environmental performance, and third, focal organization takes the lead in achieving environmental performance, and suppliers are in the supportive circle of influence. Some of the other researchers that have used ISM to analyze the interaction between various enablers include Faisal *et al.* (2007), Wang *et al.* (2008), Kumar *et al.* (2008) and Pandey and Garg (2009). Faisal *et al.* (2007) studied the interaction of information risk mitigation enablers. Wang *et al.* (2008) analyze the hierarchy of various barriers to energy saving in China, while Kumar *et al.* (2008) analyzed the enablers responsible for flexibility in global supply chain. Pandey and Garg (2009) used ISM to study the interaction between enablers of agility in supply chain.

3. ISM methodology and model development

ISM falls into the soft operations research (OR) family of approaches. The term ISM refers to the systematic application of graph theory in such a way that theoretical, conceptual, and computational leverage is exploited to efficiently construct a directed graph, or network representation, of the complex pattern of a contextual relationship among a set of elements. In other words, it helps to identify structure within a system of related elements. It may represent this information either by a digraph (directed graph) or by a matrix. ISM model also portrays the hierarchy of the enablers. The development of a hierarchy helps in the classification and categorization of the enablers, and thereby formulates their respective strategies and policies while providing clarity of thought. A model depicting relationships among key enablers would be of great value to the top management to delineate the focus areas. ISM methodology helps to impose order and direction on the complex relationships among elements of a system (Warfield, 1974; Sage, 1977). The ISM methodology is interpretive from the fact that the judgment of the group decides whether and how the variables are related. The process of structural modeling consists of several elements: an object system, which is typically poorly defined system to be described by the model; a representation system, which is a well-defined set of relations; and an embedding of perceptions of some relevant features of the object system into the representation system. Interpretation of the embedded object or representation system in terms of the object system results in an interpretive structural model (Sage, 1977).

In ISM a set of different and directly related variables affecting the system under consideration is structured into a comprehensive systemic model. Therefore, in this paper, the enablers of sustainability in a supply chain have been analyzed using the ISM methodology, which shows the interrelationships of the enablers and their levels. These enablers are also categorized depending on their driving power and dependence. The various steps involved in the ISM methodology are as follows:

- Step 1: variables affecting the system under consideration are listed, which can be objectives, actions, and individuals.
- Step 2: from the variables identified in Step 1, a contextual relationship is established among variables with respect to which pairs of variables would be examined.
- Step 3: a SSIM is developed for variables, which indicates pair-wise relationships among variables of the system under consideration.
- Step 4: reachability matrix is developed from the SSIM and the matrix is checked for transitivity. The transitivity of the contextual relation is a basic assumption made in ISM. It states that if a variable A is related to B and B is related to C, then A is necessarily related to C.
- Step 5: the reachability matrix obtained in Step 4 is partitioned into different levels.
- Step 6: based on the relationships given above in the reachability matrix, a directed graph is drawn and the transitive links are removed.
- Step 7: the resultant digraph is converted into an ISM, by replacing variable nodes with statements.
- Step 8: the ISM model developed in Step 7 is reviewed to check for conceptual inconsistency and necessary modifications are made.

3.1 SSIM

As mentioned in Section 1.1, we consulted five experts for developing SSIM. Contextual relationship of "leads to" type is chosen which means that one enabler helps to alleviate another enabler leading to the contribution toward GSCM. Keeping in mind the contextual relationship for each enabler, the existence of a relation between any two enablers (i and j) and the associated direction of the relation is questioned. Four symbols are used to denote the direction of relationship between the enablers (i and j):

(1) V: enabler i will alleviate enabler j;

(2) A: enabler j will alleviate enabler i;

(3) X: enabler i and j will alleviate each other; and

(4) O: enablers i and j are unrelated.

Based on the consensus of experts the contextual matrix (SSIM) table is developed shown in Table I. The following would explain the use of the symbols V, A, X and O in SSIM. Enabler 1 (organizational boundary) would improve enabler 2 (Informational boundary). The implementation of various informational mechanisms by an organization contributes toward greening a supply chain. At the same time, informational mechanism cannot be introduced in an organization if strategies of the company do not demonstrate economical benefits. This unidirectional forward relationship has been entered as "V" in Table I. Enabler 3 (proximal boundary) is improved by enabler 2 (Informational boundary). Information boundary is not improved by proximal boundary. This unidirectional reverse relationship has been entered as "A" in Table I. Enabler 2 (informational boundary) leads to enabler 8 (economic boundary) and economic boundary leads to Informational boundary. This mutual relationship has been entered as X Table I. No relationship seems to exist between enabler 2 (informational boundary) and enabler 4 (political boundary) so the relationship is O (Table I).

3.2 *Reachability matrix*

The SSIM is transformed into a binary matrix, called the initial reachability matrix by substituting V, A, X, O by 1 and 0 as per the case. The rules for the substitution of 1's and 0's are the following:

1. 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;
2. 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;
3. 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; and
4. 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.

Table I. Structural self-interaction matrix

X	O	V	A	V	V	O	V	(1) Organizational
X	X	A	O	V	O	A	(2) Informational	
X	O	V	O	X	O	(3) Proximal		
O	A	A	A	O	(4) Political			
A	A	A	O	(5) Temporal				
O	V	O	(6) Legal					
O	V	(7) Cultural						
X	(8) Economic							
(9) Technological								

Following these rules and after incorporating transitivity, final reachability matrix for the enablers is shown in Table II.

3.3 Level partitions

From the final reachability matrix, the reachability and antecedent set for each enabler are found (Sage, 1977). For every element p_i, we define the reachability set R(p_i) as the set of elements reachable from p_i. R(p_i) may be determined by inspecting the row corresponding to p_i, the element that column represents is contained in R(p_i). Similarly for every element p_j, an antecedent set A(p_j) is defined which is the set of elements which reach p_j. A(p_j) may be determined by inspecting the column corresponding to p_j. For every row which contains a 1 in column p_j, the element that row represents is contained in A(p_i). The elements in the top level of the hierarchy will not reach any elements above their own level. As a result, the reachability set for a top-level element p_i will consist of the element itself and any other elements within the same level which the element may reach, such as components of a strongly connected subset. The antecedent set for a top-level element will consist of the element itself, elements which reach it from lower levels, and any elements of a strongly connected subset involving p_i in the top level. As a result, the intersection of the reachability set and the antecedent set will be the same as the reachability set if p_i is in the top level. Note that if the element in question were not a top-level element, the reachability set would include elements from higher levels, and the intersection of the reachability and antecedent sets would differ from the reachability set. Therefore an element p_i is top-level element if:

$$R(p_i) = R(p_i) \cap A(p_i)$$

Once the top-level element is identified, it is separated out from the other elements. Then, the same process is repeated to find out the elements in the next level. This process is continued until the level of each element is found (see Tables A1-A5). These levels help in building the digraph and the final model.

3.4 Formation of ISM based model

From the final reachability matrix, the structural model is generated. If the relationship exists between the enablers j and i, an arrow pointing from i to j shows this. This resulting graph is called a digraph. Removing the transitivity as described in the ISM methodology, the digraph is finally converted into the ISM model as shown in Figure 1.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	Driving power
(1)	1	1	0	1	1	0	1	0	1	6
(2)	0	1	0	0	1	0	0	1	1	4
(3)	0	1	1	0	1	0	1	0	1	5
(4)	0	0	0	1	0	0	0	0	0	1
(5)	0	0	1	0	1	0	0	0	0	2
(6)	1	0	0	1	0	1	0	1	0	4
(7)	0	1	0	1	1	0	1	1	0	5
(8)	0	1	0	1	1	0	0	1	1	5
(9)	1	1	1	0	1	0	0	1	1	6
Dependence	3	6	3	5	7	1	3	5	5	

Table II.
Reachability matrix

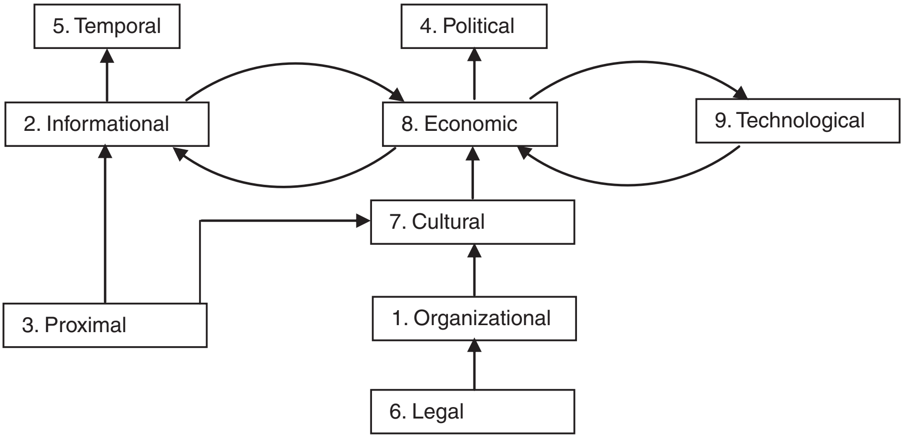

Figure 1.
ISM model for contribution toward GSCM

3.5 Matrix of cross-impact multiplications applied to classification (MICMAC) analysis

The objective of the MICMAC analysis is to analyze the driver power and the dependence power of the enablers (Mandal and Deshmukh, 1994). In a MICMAC analysis enablers are classified into four clusters. The first cluster consists of the "autonomous enablers" that have weak driver power and weak dependence. These enablers are relatively disconnected from the system, with which they have only few links, which may be strong. Second cluster consists of the "dependent enablers" that have weak driver power but strong dependence. Third cluster has the "linkage enablers" that have strong driving power and also strong dependence. These enablers are unstable in the fact that any action on these enablers will have an effect on others and also a feedback on themselves. Fourth cluster includes the "independent enablers" having strong driving power but weak dependence. It is observed that an enabler with a very strong driving power called the key enablers, falls into the category of independent enablers. Subsequently, the driver power-dependence diagram is constructed which is shown in Figure 2.

4. Discussion of results

As seen in Figure 2, there is no enabler in the autonomous cluster which indicates no enabler can be considered as disconnected from the whole system and the management has to pay an attention to all the identified enablers of sustainability in supply chains.

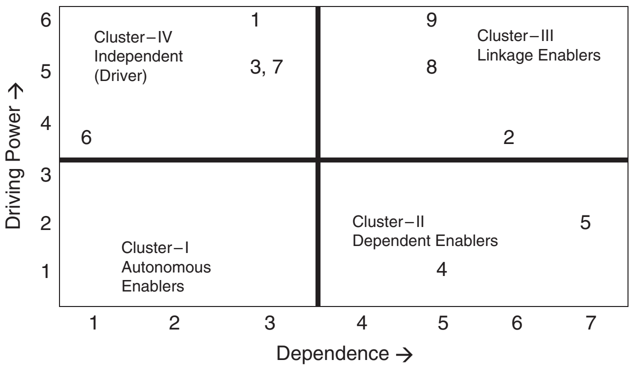

Figure 2.
Driver power and dependence diagram

In the next cluster we have independent variables like Legal boundary, Organizational boundary, proximal boundary, and cultural boundary toward sustainable practices, which have high driving power but little dependence. These enablers play a key role for integrating sustainability in a supply chain and have strategic importance. The next cluster consists of those enablers that are termed as linkage variables and include informational boundary, economic boundary, and technological boundary, which is influenced by lower level enablers and in turn impacts other enablers in the model. The three linkage enablers are interconnected in a way that information boundary facilitates the organization that at what point of time it is economically infeasible to carry on with the environmental responsibilities due to end-of-pipe or incompatible technologies. The last cluster includes enablers like "Temporal boundaries" and "Political boundaries". In this cluster particularly the Temporal boundary has highest dependence and form the top-most level in the ISM hierarchy. It represents the enabler that is the resultant action for effective integration of sustainability in a supply chain. Its strong dependence indicates that it requires all the other enablers to come together for effective implementation of sustainability practices. But it is important as it is finally required by the supply chain to measure the effectiveness of environmental sustainability practices in the supply chain. Although, the present research delineates the relationship between the key defined variables so that the overall structure could be extracted for the supply chain system, we find some industries are already practicing and imposing the pointers (enablers) considered in this paper. A few real world examples are outlined as follows.

Consistent to "Legal" enabler, European Sustainable Investment Forum presented a report in the year 2012 concerning Apple-Foxxconn labor law scandal. Following the investigation by the Fair Labor Association, both Apple and Foxconn Technology Group committed to full legal compliance regarding work hours, as well as remedial action addressing health and safety, worker representation, and compensation. However, Foxconn failed to deliver on its commitment. Recent regulatory actions, as well as global standards for the conduct of companies, have highlighted the business case for sustainable supply chain management. As the report points out, the Dodd-Frank financial reform bill mandates that companies in the electronics and other affected industries report on the sources of conflict minerals, and the California Transparency in Supply Chains Act requires that large companies doing business in the state publish policies that address slavery and human trafficking in their supply chains. Additionally, while the guiding principles on business and human rights; approved by the United Nations Human Rights Council, the document clearly establishes that companies have a responsibility to honor human rights in their operations.

"Organizations" like eBay focusses environmental sustainability right into its business plan. The online retail and auction site makes it easy for people all over the world to exchange and reuse goods rather than throwing them away, thereby lengthening the lifespan of these products so they don't wind up as trash. The company also introduced an eBay classifieds section, where individuals can buy and sell used household appliances, furniture and other hard-to-ship items within their local community, eliminating the need for shipping and packaging, and keeping functional items out of landfills. Further, because most of the environmental impact of eBay business occurs when one user ships something to another, the company targeted the logistics and delivery aspects of green supply chain management by partnering with the US Postal Service (USPS). Together, eBay and the USPS created a co-branded line of environmentally friendly Priority Mail packaging that has earned Cradle-to-Cradle™ certification.

A strong sustainability "Culture" at company level normally transferred across the whole supply chain. The key lever to implement a sustainable supply chain with a common vision and culture is the people, the actors who make the decisions in the supply chain. The best practices companies merge sustainability with their general company image. A good example is "Quality Thinking" at Mercedes-Benz, a slogan which is strongly communicated by the company since its foundation, and firmly anchored in the behavior of their employees.

The "Proximal" or the distance of a supplier from the manufacturer largely contributes to the eco-design efforts. Decisions such as locating suppliers within the organizational facilities through programs such as vendor managed inventory (VMI) have environmental implications (Handfield *et al.*, 2005). With VMI, suppliers are physically located at the organizational facility. The influence of just-in-time (JIT) delivery and management philosophies are also on the environment can be associated to physical distance and geographical factors. Toyota and Dell are the examples that follow JIT strategy. The Toyota production strategy is highlighted by the fact that raw materials are not brought to the production floor until an order is received and this product is ready to be built. Dell's approach to JIT is different in that they leverage their suppliers to achieve the JIT goal. They are also unique in that Dell is able to provide exceptionally short lead times to their customers, by forcing their suppliers to carry inventory instead of carrying it themselves and then demanding (and receiving) short lead times on components so that products can be simply assembled by Dell quickly and then shipped to the customer.

The study indicates that firms, especially small firms, benefit from increased consideration of the environment. Further, small firms can benefit from developing and proposing green "Economic" incentives. One of the most powerful aspects of the green movement is that firms of all sizes are making these changes in a transparent manner. Corporations with major green supply chain initiatives include: Wal-Mart, Procter & Gamble, IBM, and others.

As an advance "Technology", today, Radio frequency identification (RFID) is proven technology providing far-reaching benefits for transportation and logistics organizations. While many of these businesses are successfully using systems for asset management, warehouse and yard management, the future of RFID goes far beyond internal closed-loop solutions. RFID is helping to drive green initiatives such as reusable containers and other returnable transport items and recycling programs. Third-party carrier Deutsche Post DHL is currently using a Smart Truck pilot project in Berlin to test innovative route planning to deliver better customer service and lower CO_2 emissions. RFID tags and readers first ensure that the right packages are on the right truck, and then dispatch sends an optimum route based on real-time traffic conditions. Built-in GPS guides the driver to the first delivery, and RFID checks to ensure the right package has been delivered. Turn-by-turn directions are then sent to guide the truck to its second delivery and so on. The enhanced visibility provided by the RFID system confirms the status of each package at any given time, and ensures that packages are all delivered correctly, lowering fuel costs and emissions through optimized routing and reduction in the number of re-deliveries.

In the era of IT capability of "Information" some companies use ERP module designed to track and measure an organization's total carbon footprints. Danone, a consumer products company used SAP-ERP system to measure carbon footprints and was able to reduce carbon footprints by 30 percent from 2008 to 2012.

Water is a critical input to agriculture and many industrial processes. Globally, industries are facing constraints from water accessibility. With a rising population, intensive urbanization and rapidly growing economies, water scarcity and pollution has become a major issue to business (Esty and Winston, 2009). Companies that use too much water or degrade water quality are facing "Political" attack (Esty and Winston, 2009).

In view of above discussion we find that most of the enablers considered in this paper are already being pursued by various organizations.

5. Conclusion

The ISM model developed in this paper clearly portrays that for carrying out green practices, the supply chains require that each echelon within a supply chain should morally and ethically be involved in environmental sustainability as these can be considered as the attributes of legal boundary (Sarkis, 2012). Similarly, extraneous to proximity, may be at international level, or at individual, group, and organizational levels, the management should inculcate the culture of environmental sustainability. Further, the model portrays that it is imperative that "Information boundary" leads to "Temporal boundary" which clearly indicates that time is the ultimate action for environmental sustainability. This validates the statements made by various researchers mentioned in Section 1 that lean practices through information coordination within an organization and timely information from consumers for re-evaluating the supply chain is imperative from environmental sustainability perspectives. Under political boundaries, the issues of power and trust at organizational and inter-organizational level play a significant role toward environmental sustainability. However, it may largely depend upon cultural boundary context.

Toward this end, the present paper is an attempt in the direction to identify the key enablers which affect the environmental sustainability decision. The hierarchy of enablers through ISM model and subsequently through MICMAC analysis provides a useful tool to supply chain managers to differentiate between independent and dependent variables and their mutual relationships which would help them to focus while making decisions while designing a green supply chain.

Further, this paper is limited to only implication of ISM methodology in modeling the enablers of environmental sustainability of supply chain at broader level. In other words, we have not been specific to any level of GSCM as mentioned in Sarkis (2012). There is scope for further research by developing a broader consensus on the order of levels of these enablers, especially in the context of RSC, and studying separately their impact on the performance of FSC. For instance, a time based performance can be analyzed for a closed-loop supply chain when different scheduling decisions are adopted at operational level under the premise of symbiosis of information boundary and temporal boundary so as to mitigate system wide cycle time and thereby saving energy. Each boundary can be explored to sub-dimensions. For instance, given the technology up-gradation in an organization, how various enablers specific to ERP setup have hierarchical effect on environmental sustainability toward greening the supply chain can be another issue to explore.

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Appendix

Table A1.
Iteration 1

Element p_i	Reachability set R(p_i)	Antecedent set A(p_i)	Intersection R(p_i)∩A(p_i)
1	1, 2, 4, 5, 7, 9	1, 9	1, 9
2	2, 5, 8, 9	2, 8, 9	2, 8, 9
3	2, 3, 5, 7, 9	3, 5, 9	3, 5, 9
4	4	4	4
5	3, 5	3, 5	3, 5
6	1, 4, 6, 8	6	6
7	2, 4, 5, 7, 8	7	7
8	2, 4, 5, 8, 9	2, 8, 9	2, 8, 9
9	1, 2, 3, 5, 8, 9	1, 2, 3, 8, 9	1, 2, 3, 8, 9

Table A2.
Iteration 2

Element p_i	Reachability set R(p_i)	Antecedent set A(p_i)	Intersection R(p_i)∩A(p_i)
1	1, 2, 7, 9	1, 9	1, 9
2	2, 8, 9	2, 8, 9	2, 8, 9
3	2, 3, 7, 9	3, 9	3, 9
6	1, 6, 8	6	6
7	2, 7, 8	7	7
8	2, 8, 9	2, 8, 9	2, 8, 9
9	1, 2, 3, 8, 9	1, 2, 3, 8, 9	1, 2, 3, 8, 9

Table A3.
Iteration 3

Element p_i	Reachability set R(p_i)	Antecedent set A(p_i)	Intersection R(p_i)∩A(p_i)
1	1, 7	1	1
3	3, 7	3	3
6	1, 6	6	6
7	7	7	7

Table A4.
Iteration 4

Element p_i	Reachability set R(p_i)	Antecedent set A(p_i)	Intersection R(p_i)∩A(p_i)
1	1	1	1
3	3	3	3
6	1, 6	6	6

Table A5.
Iteration 5

Element p_i	Reachability set R(p_i)	Antecedent set A(p_i)	Intersection R(p_i)∩A(p_i)
6	6	6	6

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