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Environmental Pressure Driven Flexible Green Supply Chain: A Decision Modeling Perspective

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Abstract

Consideration is being given to the interaction of flexibility and green perspective of supply chains. Flexibility has already been considered to be an important differentiator in the current market place. Several researches has already emphasized the need for flexibility in supply chains and demonstrated its effectiveness. Substantial research efforts are still required to incorporate flexibility with a motivation to improving performance of green supply chains. By understanding how organizational initiatives and government policies we can decision flexibility into design and management of green supply chains. In doing so, we will initially focus on environmental management perspective. Here decision perspective from environmental factors is moved to the technological decisions related to post-disposal disposition of products. In the present scenario this is a critical topic that captures increasing concerns of organizations over sustainability, which driven by government legislation and environmental pressures. Implication of this research emphasizes on potential to affect future government policy, current production system, and identify new business models. In furthering this analysis, we investigate and provide a background to better understand current trends in this multidisciplinary field that intersect with green supply chain.

***Keywords**: AHP, Cognitive mapping, Flexibility, Green supply chain management, Green supply chain, Impact wheel, Reverse logistics, Sustainable development*

Introduction

Sustainability and going green with flexibility are not terms that managers can avoid any longer. For years environmental responsibility has been increasing in importance not only with managers, but also consumers who grow more aware as well as other stakeholders affected by unsustainable business. Due to environmental consideration, green supply chain proves to be an attractive area for researchers and the growth in this green supply chain management literature extends back to the early 1990s with the advent of corporate environmental issue, environmentally focused manufacturing policies, and i.e. “environment concern”. While, in mean time many researchers have explained the application and importance of green supply chains in various manners. Wang, *et al.,* (2004) demonstrated its importance in reducing and limiting carbon emissions and waste by closing the loop of a supply chain. Also, the sustainability of green supply chain is increasingly recognized as a vital component of corporate perspective and sustainability is explained as an art to manage environmental, social and economic aspects, and the encouragement of good governance practices in a supply chain (Linton, *et al.,* 2007).

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With growing awareness, environment becoming major concerned issue in green supply chain (Zhu and Zhao, 2004 & Srivastava, 2007). Moreover, green supply chain organization comprised of several departments within the structure that work together closely to fulfill the needs of consumers and maximization of productivity (Vachon and Klassen, 2006). With increasing attentions of preserving natural resources worldwide, the green trend of going with sustainability and protecting the environment is overwhelming, thereby exerting pressure on corporations in world. Today, in highly competitive (mature) markets, supply chain management (SCM) play very important role has for firm's growth, and we have recently seen, also in performance downturns. In today market place, liberalization and globalization together with the changing demand of the consumer are crucial drivers for the growing competition. (Giannoccaro, *et al.,* 2003) demonstrates the several aspects of 'flexible'- green supply chains encompasses with changing market demand, differing supplier lead time, product quality and information delay are sources of uncertainty that create a need for building environment focused system that and preferably in a better way than their rivals.

In today's manufacturing climate, the organizations are trying hard to reduce wastage and towards quick responsive supply chains to increase their performance. Also, because of government legislation, the potential for recovering economic value, and consumer demand for green" practices the producers are being compelled to incorporate flexibility and reverse logistics into their supply chains. The pressure and drive accompanying globalization, a crucial aspect for supply chains has prompted and motivated enterprises to improve their environmental performance (Zhu and Sarkis, 2006). Further, with the advent of rules and various regulations pressure and changing customers taste the corporations have shown great concern for the environment over the past few years (Sheu, *et al.,* 2004). Besides this globalization, the localization pressure also plays significant role in improving their environmental performances (Sarkis and Tamarkin, 2005). Madu, *et al.,* (2002) emphasizes to incorporate economical performance into the preplanning of strategies, environmental concern should be a part of the overall corporation culture. Further, for any organization the environmental issues becomes crucial these days but at the same time flexibility and cost aspects associated green supply chain should be examined. Srivastava, (2007) explains the application of green principles in many departments within organization, including supply chain. This idea covers every stage in manufacturing from the first to the last stage of life cycle, i.e. from product design to recycle and emphasis on environmental concern. In this work, we focus on interaction of flexibility and green i.e. environmental perspective in a supply chain that led a sustainable behavior with consideration of environmental pressures.

Motivation

For the purpose of this paper, environmental pressure driven flexible green supply chain and its implication has researched. In early environmental management literature, operating managers and executives were involved only at limited extent. There was the need of separate organizational units in product development, process design, operations, logistics, marketing, regulatory compliance and waste management to excel and ensure environmental achievements. Today, this has changed. Moreover, the quality revolution of the 1980s and supply chain revolution of the 1990s, suggests that the integration of environmental perspective and flexibility of the system with ongoing process proved to be best practices for sustainability and economic growth for an organization.

Current market nature and demand behavior already emphasized the need for flexibility and green perspective in their supply chain practices. While, the possibility to respond to short term fluctuations in demand or supply situations of other external disturbances together with the adjustment to, operational, strategic and structural changes in the behavior of the supply channel

considering environmental pressures can be termed as the flexibility in green supply chains. But, substantial research reviews are still required to incorporate flexibility with a motto to improve the productivity of green supply chains. Further, we concentrates on what is already happened in the this field and what marks can be defined for further research, considering the recent practices in green supply chain management as well. In order to fill the research gap as stated above, we collected a wide variety of literature, trying to analyze the issues from a broad perspective. This paper investigates current situation of developing flexible green supply chains. Our target objectives are to study and integrate green flexibility in a supply chain, which can handle environmental pressures and responds to demand quickly as well. We also use impact wheel diagram to study the problem systematically and further rank the various criterion associated with a flexible green supply chain using AHP method. In addition, figure out certain critical aspects that should be improved in carrying out flexible green supply chains and highlights some valuable remarks.

The further sections of the paper are characterized as follows**.** Green supply chain management, green supply chain, their importance, implementation and the term flexibility and it's interaction with green supply and its importance is explained in section 3.Impact wheel diagram illustration under a tool; cognitive mapping along with multi criterion decision making technique (AHP method) to rank the various parameters/criterions is demonstrated in section 4, succeeded by discussion and conclusions and scope for future work in Section 5.

Green Supply Chain Management

In era of competition, Environmental awareness and sustainability regulations have been putting pressure on many producers and consumers, to produce such products which can be disposed off easily. Hervani, *et al.,* (2005) sketches green supply chain management (GSCM) in the form of an equation. They demonstrated that reverse logistics is a major component of GSCM as it turns a forward supply chain into reverse after closing its loop:-

GSCM = Green purchasing + Green manufacturing + Green distribution + Reverse logistics

Although general agreement about the definition has not been reached, academic authors however do realize that environmental standards in supply chains are important and greening the four aspects mentioned above is an absolute necessity to stay competitive. For enterprises, environmental management can be regards as a start of sustainability development. Pressures from government and customers lead corporations to adopt environmental management, which mainly aims to reduce environment pollutions and cut natural resources consumptions. It is essential for companies to add sustainability into their strategy level, since it helps to gain and maintain competitive advantage. Nevertheless, one thing should be emphasized is that sustainable strategy should be consistent with organizations business goals, because putting sustainability into practice is more likely to change the internal structure. On one hand, sustainability initiatives of a firm and its corporate tactics always overlap and interact with each other (Srivastava, 1995). It is impossible to manage one of them separately. On the other hand, fundamental changes in core business processes are required when company transfers the sustainable strategies into practice. Savitz and Weber, (2006) argue that when firms choose to become sustainable enterprises, they are able to integrate corporate governance mechanism with sustainability initiatives. In fact, the priority of a firm is profit maximization whereas some supply initiatives may hurt the goal. To better achieve sustainability and with emphasizes on minimizing environmental influences, there are a series of articles refer to green supply chain management. Srivastava, (2007) gives most widely used definition of green supply chains i.e. "integrating environmental thinking into supply-chain management, including product design, material selection, manufacturing and processes, delivery of the final product to the consumers

(distribution processes) as well as end-of-life management of the product after its useful life". It focuses on conserving energy and preventing disposal of dangerous materials into the environment by eliminating or minimizing the wastes within the industrial system (Bansal and Roth, 2000 & Shalishali *et al.,* 2009).

Green word stands for go i.e sustainable but not on account of compromise with environmental loss, social aspects, performance issue and economy. Green supply chains differs significantly from traditional supply chain and for today managers needs to be used of this term and facilitate in their organization and should take appropriate steps when carrying out it. Generally, green confines wastes generated by procedures along supply chains. It is a practical approach for company to be sustainable It is obvious that green supply chain is more concerned on environmental issues. Shalishali, *et al.,* (2009) highlighted the various aspects to differentiate green supply chain from traditional supply chain. Those differences can be divided into five perspectives: the objectives and values, the scope, supplier selection criteria, cost pressure and prices, speed and flexibility as shown in Table 1. Furthermore, Hock and Erasmus, (2000) argues that green supply chain management can impel organization to achieve win-win situation. Green supply chain management proves to be highly profitable along with concentrating on environment perspective (Srivastava, 2007). Moreover, companies also understand the economic benefits such as value maximization, competitive edge via applying green supply chains.

Table 1: Difference between Traditional Supply Chain and Green Supply

Aspects	Supply chains	Green supply chains
Objectives and Values	economic motivations- control offinal products	ecological causes - production process
Scope	merely consider human toxicological effect	pay attention to environment
Supplier Selection Criteria	price is the key factor- easily switch suppliers	consider ecologicalperspectives of suppliers- long term relationships
Cost Pressure and Prices	low price	high price
Speed and Flexibility	High	low

However, green supply chain management might results slightly improved environmental and operational performance but has not resulted in significant improvement in economic performance (Zhu, *et al.,* 2008). It illustrates that green supply chains is a long-term investment and results some promising benefits in future.

Various Aspects of Implementation of GSCM Practices

There are various drives or pressures upon companies to implement GSCM. Zhu and Sarkis, 2006) listed some of them as regulations, marketing, suppliers, competitors and internal factors. The demands of regulations can't be solely cause of environmental protection because consumers and clients also pressurize respective organizations (Hall, 2000). Further, (Sarkis, 1998) explains regulations, standards, policies and competition have together helped organizations to better understand of any consequences for the environment. On the other hand, the organizational, regulatory, community and media stakeholders have helped companies to study and analze environmental management effectively (Henriques and Sadorsky, 1996). While, according to Zhu and Sarkis (2006); Hall (2000) & Sarkis (1998) external stakeholders and environmental regulations are considered the significant factors affecting GSCM practices.

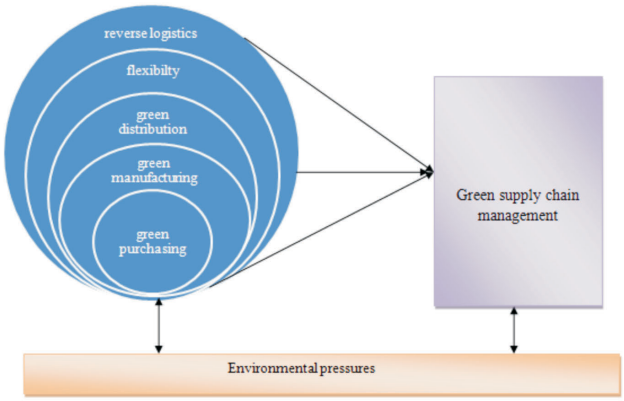

Figure 1: Research Framework of GSCM Practices

Here in this work, we focus on some significant components of a multidimensional decision environment that a management faces. Given among the various components are influences and relationships of the life cycle of product, green operational life cycle and environmentally focused regulations driven by environment pressures and organizational performance measurements. These elements act as the base for a decision framework for prioritizing systems by the organization that will aid in managing flexibility in green supply chains. Also, environmental pressure drives the green supply chain and the relationships between green purchasing, green manufacturing, green distribution, flexibility, reverse logistics and economical performance will be discussed through the a literature review, and hypotheses relating these variables will be developed as shown in Figure 1.

Influence of Product Life Cycle

The product life cycle of the product(s) considered as important factor that influences the management of a supply chain in an organization. This typical product life cycle is composed of four phases; an introduction phase which is defined as the by investment in product research and development, a growth phase includes the increase in production capacity and logistics network of product, a maturity phase, characterized by implementation of process and cost efficiencies, and last decline phase characterized divestment of product. The product life cycle phase will necessarily affects the greening and flexibility in supply chains.

The Green Operational Life Cycle

The operational life cycle provides a strategic set of organizational components that will shows how the supply chain is to be managed within an organization. Green purchasing, green production, green distribution, flexibility and reverse logistics etc. being stated as the major elements of the operational life cycle. The purchasing of materials that are easily disposed, recyclable, or reusable or have already had been recycled affects the green supply chain considerably. The vendor's selection will also be crucial decision at this stage. Vendors carrying ISO 14000, certification may be preferred because the environmental risks associated with these vendors will be less. The greening of the supply chain affected greatly by production processes and can be demonstrated: capability of a process' to use certain materials, to integrate remanufactured/recycled or reusable elements into the system and how well the processes are designed and planned to minimize the wastage. Distribution of product to the distributors' and transportation channels are also significantly affect the green supply chain. This includes a number of decisions including number and locations of distribution centers, possible mode of

transportation, control systems, and just-in-time and inventory policies, those not only influence the forward channel, but also the reverse channel. Flexibility in supply chains may be stated as the characteristic to respond to short term fluctuations in demand or supply pattern along with the managing strategic and structural changes in the environment of the supply chain. It is recommended that flexibility enables a supply chains to react on changing customer demand. While, last but not the least the reverse logistics operation is probably the least developed and studied from operational functions perspective. Tibben-Lembke and Rogers, (2002) defined reverse logistics – 'the process of moving goods from their typical final destination for the purpose of capturing value, or proper disposal.' Reverse logistics includes various activities such as return products to supplier, resell, sell-via-outlet, reconditioning etc. Further, Pohlen and Farris, (1992) identified a number of stages within a reverse logistics network i.e. collection, separation, densification, transitional processing, delivery, and integration. They explain that along with the network for the reverse logistics collection process, a number of systems and processes may need to exist for the stages in the reverse channel. Moreover, the requirements may vary among the stages as per the type of product, organization and industry**.**

Various Aspects Involved in Implementation of Green Supply Chain Management

Considering why firms apply green supply chains, a series of literatures argue that environmental policies and regulation are major driver contributes to implementation of green supply chains and impel to conduct green supply chains into practice at the same time. Legitimation reflects the inclination of a company to enhance their actions under the instruction of certain regulations, norms, values or beliefs (Suchman, 1995). According to Bansal and Roth (2000), corporations who regard regulations as one of their incentives often set up environmental policies in order to comply with environmental regulations. For instance, taking those regulations into consideration, firms began to notice the importance of cooperation with suppliers in order to satisfy environmental requirements. Moreover, for firms that pay special attention to legitimation, stakeholders are more influential in stressing legitimacy concerns. These Environmental concentrated legislation or campaigns playing a crucial role in managing solid waste and therefore affect the fraction of used products that are properly collected and handled. Within a supply chain, these influences may affect directly or indirectly yet the consideration of a take-back obligation for the original manufacturers or the merchandisers is said to be direct. While, an indirect influence may be in the form of penalty for each uncontrollably disposed product i.e. take-back fee included in the price of the product, which to be paid back when the product is returned to a proper collection point.

Environmental pressures directly drive green supply chain management as being shown in Figure1. Traditionally, external systems impact a lot on the decisions and behavior of an organization; various elements within external systems are regulations, professional standards, the law, interest organization and social belief (Oliver, 1991). Meyer, *et al.,* (1987) explained the effects of external pressures on organizational structure. In this study, we examining the effect of environmental consideration in a flexible green supply chain and various elements studied under the Environmental regulations stated as domestic environmental regulations, government environmental policies and international environmental agreements according to Zhu and Sarkis,(2006); Hall, (2000); Sarkis, (1998) etc. Further, these considered elements under environmental rules and regulations are explained as below.

Domestic Environmental Regulations

This is a very important element under environmental pressure and national/domestic law can be defined as legal system applicable to a defined territory over which a sovereign power has jurisdiction. These domestic or national environmental regulations and laws prompt organizations

to adopt relevant strategies and methods to enhance their productivity and environmental performance. (Zhu and Sakis, 2006) find out that for an organization, stated domestic regulations and corporations environmental missions acted as important driving pressures. Furthermore, (Handfield, *et al.,* 1997) explains the importance of government regulations for a corporation and described this major driver to increase environmental awareness among them.

The role of Government and Various Agencies

In order to create competitive markets and protecting the environment, Government implementation and enforcement of domestic rules and regulations plays an important role for safeguarding individual rights. There are many countries around the world that have laws focusing these environmental issues, but due to lack of resources and an inadequate institutional infrastructure some countries can't effectively executes these laws. The only long-term solution to such barriers is for governments to create an healthy environment for investment-led domestic growth that will provide the necessary resource base to initiate and implement the law on all companies. Hui, *et al.,* (2001) explains that environmental conscience is increasing among the masses and for company's perspective, the statutory requirements due to government rules and regulations, and various other pressures from different groups are traditionally considered to be important drivers towards adopting a green implementation policy. These Government regulations and standards have a very significant impact on the GSCM practice. Moreover, there are large number of government agencies controlling guide line, regulation and rules in United States. It is also examined that the some agencies are controlled by the government while some manage only in the local area. These agencies and corporations are responsible for various similar and different issues such as effect of industrialization, sustained growth perspective and how to manage solid and chemical waste. Furthermore, the Environmental Protection Agency (EPA) a government organization established to protect the environment and concerned with human health. ISO 1400 series is an example of environmental guide line. It was formally adopted in 1996 by the International Organization for Standardization (ISO) and represents a model of new standard and policies for improving environmental performance.

International Environmental Agreements

International environmental agreements significantly affect green supply chain management. Various international environmental agreements across all over world, such as the Kyoto agreement, the Climate Change Treaty and the Montreal Protocol influence the performance behavior of enterprises and organizations. The Implementation of agreements depends on political will which frequently lacks strong compliance provisions. Further, (Gottberg*, et al.,* 2006), explains that although domestic environmental regulations seem to have a greater and valuable effect on eco-design but the impact of international policies associated with waste electrical and electronic equipment can't be underestimated.

External Stakeholders such as Suppliers and Customers

In 1984, Freeman published his book titled Strategic management: stakeholder approach and explains the importance of stakeholder such as suppliers and customers etc. (Hervani, *et al.,* 2005) explains the importance of external stakeholders in green supply chain management .(Greenwood, 2001) defined stakeholders as the inclusion of any group or individual who can affect or is affected by the corporation. According to Henriques and Sadorsky, (1996) and Hall (2000 & 2006), major external stakeholders of GSCM process generally consists of customers suppliers, and community stakeholders. The relationships between Supplier and manufacturer are considered important in developing a sustainable competitive advantage (Cannon and Homburg, 2001).While, (Sarkar and Mohapatra, 2006) found out that the suppliers play an

important role in increasing the overall performance of a supply chain, and poor supplier performance affects its performance adversely. While, the screening of suppliers has now become a key deciding factor for regulating the environmental performance in many organizations (Clark, 1999). Customer the ultimate users are the deciders and determined as the most important type of external pressure (Doonan, *et al.,* 2005). Zhu and Sarkis, (2006) explains that a within a supply chain, customers are the ultimate deciders although environment should be highly focused issue but associated necessarily environmental characteristics of products and services must satisfy customer needs. Today, consumers can pay for environment, according to a study report in U.S.A. the buying decisions of 75% of consumer's influenced by organizations environmental reputation. Furthermore, Sarkis, (2003) illustrates that the implementation of the natural environment organizational decisions not only influences the organization that makes the decision, but also its customers and suppliers.

Why Firms Consider Carrying out Green Supply Chains

During past few years, Green supply chain (GSC) is gaining increasing interest among academicians and developers of supply chain management. This growing importance of GSC is driven mainly due to increasing environmental awareness and motivation of preserving resources for future generations. Moreover, GSC is primarily not just environmentally concerned but it also shows a good business perception and generates economic benefits in long run. However, a sustainable and green supply chain can be described as the process of using environmentally friendly processes and methods in form of inputs and transforming these inputs through change agents - whose byproducts can improve or be recycled/reuse/remanufactured within the existing environment. GSC demands of today because environment a base for sustainability and for better and long run performance should be focused.

A number of articles investigate why firms carry out green supply chains and offer in-depth analysis of several drivers. Sarkis, (1997) argues that there are two types of drivers that drive firms took environmental performance into consideration. The first driver is reactive pressures which include governmental and legal regulations and preservations. The second driver is proactive pressures that can lead to sustainable competitive advantages. However, Zhu and Sarkis, (2006) classify those drivers into five dimensions: various rules and regulations, marketing strategies, suppliers behavior, competitors and other internal factor. While, the most frequently quoted drivers are: impact of competitiveness, government regulations, social changes and preference of customers (Sundarakani, *et al.,* 2010). In addition, some authors state that primary stakeholders may have a more significant influence on the firm's environmental performance. Among certain drivers, we concentrate and explained some crucial drivers before i.e. environmental regulations & policies, role of government and effect of external stakeholders such as suppliers and customer to implement green supply chain management program.

Flexibility and Green Supply Chains

Flexible green supply chain corresponds to the responsiveness of the system considering environmental issues come into existence for those situations where demand is either unstable or fluctuating. As per recent developments in the literature of SCM, quick responsive and low cost supply chains have been listed as the important aspects for the organizations. Moreover, We have already been studied the importance of green supply chains but in corporate market, green supply chains may work perfectly in steady conditions but these supply chains are not high speed responsive and not being able to react on sudden changes in demand. Growing competition and advancement in technology emphasize the need of detailed study of current market conditions which require supply chains that are capable of handling sudden fluctuations in demand and strategies. (Giannoccaro et al, 2003) find out certain sources of uncertainty i.e.

market behavior, quality of product, competition and information delay which further creates a need for building environmentally concern "flexible green supply chains". However, flexibility is being described as the ability of a supply chain to effectively manage or react to changes with little penalty in cost, time, or performance given by (Viswanadham and Raghavan, 1997) whereas the fundamental goal of flexible green supply chains are to create customer value. Also, the marketing with green perception plays an important role in achieving it. Because without suitable marketing activities, a supply chain can't anticipated the desires of customer (Rainbird, 2004). Further, the flexible ability of an organizational supply chain has been described in terms of three distinctive components (Lee, 2004). These components are general characteristics of integrating flexibility with green supply chains and are given as below:

1. Adaptable: Capable of adapting (of becoming or being made suitable) to a particular situation in current volatile market is termed as adaptability of green supply chains. To attain sustainability it proves to be a very important component. It involves certain adjustment in the design of supply chain to compensate structural fluctuations in markets, modify supply channel frameworks, methods and technologies.
2. Alignment: The act of adjusting or aligning the parts of a device in relation to each other within a green supply chain is called as the alignment. Adjust is a little word but means a lot and it involves creation of inducement along the various horizontal and vertical partners within the green supply chain for enhancing overall productivity.
3. Agility: A green supply chain should be agile enough to compensate shifts and changes in demand. Agility means market sensitiveness, representing the ability of green supply chains to responds to the actual demand in market. The real philosophy behind agile paradigm has a motto of improved customer service by speedy response to their demands. Further, agility described as a well executed business idea in flexible manufacturing system (Christopher *et al.,* 2006).

All three components described above are considered to be important aspects of flexibility. Further, these all considered as a prerequisite for a green supply chain in order to manage various uncertainty because a green supply chain can only sustain in volatile market when common agreement is made among all supply chain partners along with preplanning of strategies is also necessary. Briefly, flexibility in green supply chains is defined as the ability to respond to short and long term fluctuations in demand or supply situations along with adjustment to strategic and structural changes in supply chain's behavior driven by various environmental pressures.

Cognitive Mapping Applicability: A Tool to Identify and Solve the Cause of Problem

Over the last decades, causal maps emerged as an interesting tool for operations managers. These maps are very simple to use and easy to work. This technique is proving a very useful tool for academicians and researchers in certain ways. They can provide clear graphical representation of a problem and also acts as diagnostic tool which helps the user to identify and solve the various causes associated with the problem. From the quality improvement and operations management perspective, causal maps have been given different names, such as fishbone (Ishikawa) diagrams, issues trees, impact wheel diagram and, cause and effect diagrams. Hays and Hill, (2001); Meyer and Collier, (2001) demonstrated the usability of causal maps as a basic tool for framing and communicating a comprehensive theory, particularly in support of research based on experimental findings and results. In this work, applicability of causal mapping with impact wheel diagram has been used to study and solve the problem. The detail and construction of impact wheel diagram given as ahead.

The Impact Wheel Diagram

The impact wheel can be termed as visional tool; explores the future i.e. opportunities and possibilities associated with an event (Anonymous, 2004). It is a worldwide accepted method to solve a problem qualitatively and found applicability in many firms, private and government organizations. By understanding this tool, managers can easily cover and manage both unexpected and unintended consequences of a decision. It can be named as a simple structured brainstorming process designed to help experts while solving a problem. Moreover, this method also has some own limitations. For example, the subjectivity in decision making and its dependence over judgment of experts. In spite of this, it provides an opportunity to fully understand the potential consequences of specific change and to identify various causes associated with it that they might otherwise fail to anticipate. In this work, we have discussed the impact of environmental pressures on flexible green supply chain. Moreover, shaded elements showing in Figure 2 has been described above.

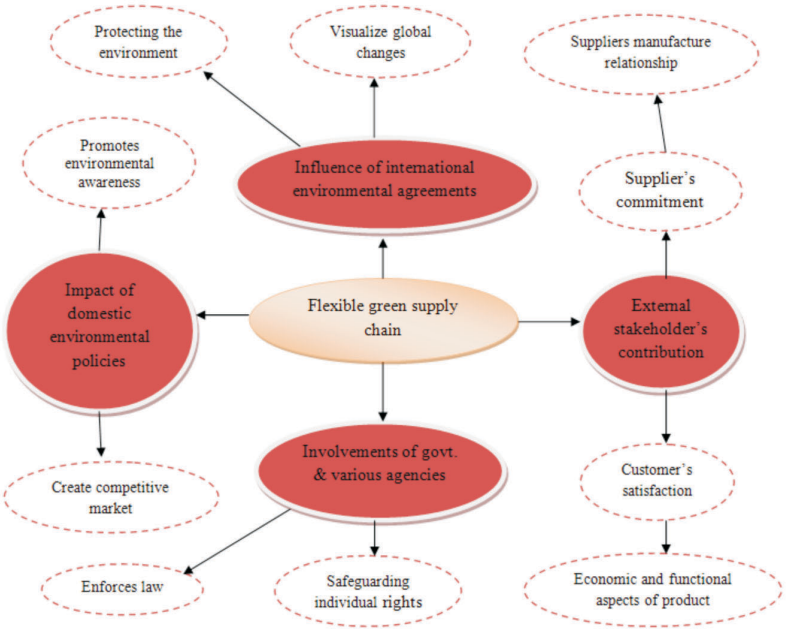

Figure 2: Environmental Pressure Impact Diagram for Flexible Green Supply Chain

Now, we discussed construction of this diagram, starts with the writing the name for the change/ event or decision to be made, in a circle in the center of the paper i.e. flexible green supply chain as being shown in Figure 2 and then collects the opinion of expert team members take part in session. The major concerned focuses are –

1. Illations- it shows the "impacts" of the specific event or decision to be made (can be illustrated as the spokes of a wheel drawn as shown in Figure 2).
2. The probabilities – finding the chance of occurrence of event/change or the likelihood for each impact.
3. The implications – examination of certain crucial factors associated with each impact i.e. cost and other benefit resultant by specific event or decision.

After considering all these above mentioned concerns a well represented impact diagram for the problem generated but still we not able to rank major and crucial illations associated with

specific change or decision. Therefore, the process cannot stop there and further need a decision making process for the final ranking of various criterions/parameters associated with flexible green supply chain driven by environmental pressures. This process needs to be well executed, in a manner which facilitates flexibility and green perspective in supply chains. At this practice, it requires some degree of quantitative aspect to solve the stated problem and further a decision making model was proposed using analytical hierarchy process (AHP method), explained as ahead.

Analytic Hierarchy Process

In this section we provide an brief introduction to AHP along with general methodology. This methodology has been proposed by Saaty, (1980) to support multi-criteria decisions, where „analytic states that the problem is broken down into its constitutive components and „hierarchy states that a hierarchy of the constitutive components is drawn in relation to the main objective. AHP has proved very promising results and found its applications in selection of alternatives, planning of decision or particular process, optimization and allocations of resources, sectors such as the manufacturing, education, industry, engineering, government and many others (Saaty, 1990 & Vaidya and Kumar, 2006). Moreover, this method has been used to solve many complex decision making problems and can be characterized as a MCDMs technique that can combine both quantitative and qualitative aspects effectively during ranking/evaluation of alternatives. During application, initially starts with the determination of relations between the elements of the problem, followed by the building of a hierarchy and finally consistency check whether a feasible solution or not. An advantage of the AHP over other multi-criteria decision techniques is that it is designed to incorporate tangible as well as intangible criteria of the decision process.

The AHP steps described below can be best understood through a discussion of an example application. Consider an example as shown in Figure 3. In this example the decision problem is to rank various parameters/criterions associated with flexible green supply chain considering environmental pressures. Various qualitative criterions are listed in the below Figure 3. AHP will be utilized to determine the highest-ranking parameters for flexible green supply chain based on these qualitative considerations. While, this method also has some limitations like decision making is based on the subjective judgment/experience of the decision maker(s). Further, various steps in the AHP method for decision making grouped into three categories and is given as:-

a) Constructing the Hierarchy

Step1. It involves definition of decision to be made and ultimate desired goals. Here the decision problem is to achieve a flexible green supply chain.

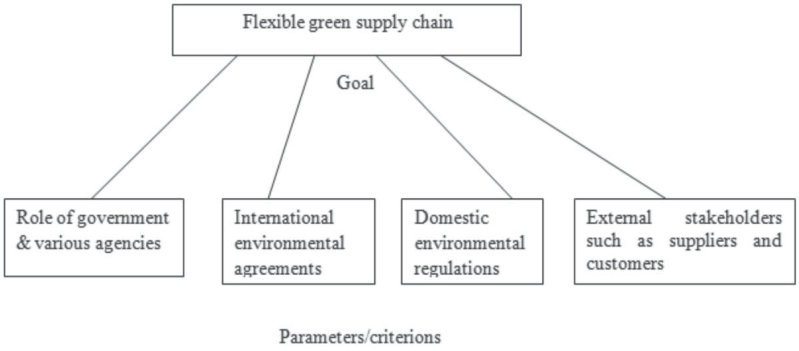

Figure 3: Decision Hierarchy

Step 2. It starts with the creation of hierarchy from top proceeds towards lowest level considering the intermediate as well. After a clear idea about criteria and the alternatives, the expert developed a decision hierarchy. It is recommended that the hierarchy composed of at least three levels, a goal, criteria and alternatives. But, if the problem is simple and can be solved easily then number of levels may be lessened. Further, in this study, there are only two levels represented by some elements as ultimate objective and various selected parameters/criterions required to achieve goal further these elements are shown in a decision hierarchy (see Figure 3).

b) Setting Priorities

Step3. It involves the construction of matrices after analyzing pair wise comparisons for various criterion/parameters listed in the study. The decision-maker chose nine-point scale for expressing his or her intensity of preference between listed criterions. Further, a value of 1 is given in the comparison, if two criteria are of equal importance while, a value of 9 is given in the comparison when one criterion has absolute importance over the other. The AHP uses a scale given by Saaty, (1980) to measure the different weights as shown in Table 2.

Table 2: Measurement Scale for Preferences between Elements

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over other	The judgment is to favor one activity over another.
5	Essential or strong importance	The judgment is strongly in the favor one activity over another.
7	Demonstration importance	The judgment as to the importance of one activity over another.
9	Absolute importance	The judgment in the favor one activity over another is of the highest possible order of affirmation.
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed.

Step 4. Here, in this step we make pair wise comparisons among all elements, may be “n” in each level which can be written in a (n × n) evaluation matrix A in which every element aij = wi/wj is the quotient of weights of the criteria. Let C = {Cj lj= 1, 2,. . ., n} be the set of criteria. Moreover, the relative priorities may be described as the right eigenvector (w) relative to the largest eigenvector (maximum), as AW = max*W- (1)

$$A = aij = \begin{pmatrix} 1 & W_1/W_2 & W_1/W_n \\ W_2/W_1 & 1 & W_2/W_n \\ \cdots & \cdots & \cdots \\ W_n/W_1 & W_n/W_2 & 1 \end{pmatrix}$$

Further, it is stated that, the matrix A has rank =1 and max =n when the pair wise comparisons are completely consistent. In these cases, weights can be obtained by normalizing any of the rows or columns of matrix A. The procedure stated above is repeated for all levels in the hierarchy.

c) Consistency Check:

Step 5. After writing all pair wise comparison, next step is to check the consistency of matrix. Saaty (1980) described that the maximum value of eigen value, ë, of a reciprocal matrix A is always greater than or equal to n (no of criterion/ parameters selected). Further, if, ë = n then pair wise comparisons are said to be consistent. The closer the value of computed ë to n, the more consistent the written maximum pair wise comparisons. Now, the Consistency Index (CI), which indicates the inconsistencies of pair wise comparisons, is computed as:

CI = (ë max- n) / (n - 1) -(2)

The final consistency ratio (CR), an index to conclude whether the evaluations are sufficiently consistent, may be defined as the ratio of the consistency index (CI) and the random consistency index (RI), which is shown in Table No. 3. Moreover, if the ratio CI/RI < 0.10, the system is consistent enough, but if CI/RI > 0.10, serious inconsistencies might exists. It means applied AHP method unable to generate meaningful results and then whole procedure has to be repeated to improve the consistency of the system. Further, it can be drawn as that the measurement of consistency directly linked with the effectiveness of decision makers as well as the consistency of all the hierarchy.

Table 3: Consistency index

Matrix rank	1	2	3	4	5	6	7	8
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41

Procedure: This section involves mathematical calculations and computations as per steps listed above in AHP method. Further, decision makers began to compare the parameters/criterion considered (from Table 2) and resulted square matrix is written as below.

- Let us represent, A= Role of govt. and various agencies, B= Domestic environmental regulations, C= International environmental agreements, D= External stakeholders such as suppliers and customers.

	A	B	C	D
A	1	5	6	8
B	$\frac{1}{5}$	1	2	4
C	$\frac{1}{6}$	$\frac{1}{2}$	1	2
D	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	1

	A	B	C	D
A	1	5	6	8
B	0.2	1	2	4
C	0.16	0.50	1	2
D	0.125	0.25	0.5	1
	1.491	6.75	9.50	15

Sum of column A= 1.491, Sum of column B= 6.75, Sum of column C= 9.50, Sum of column D= 15.

- After dividing each element of above written matrix by their respective column sum

	A	B	C	D		
A	0.67	0.74	0.631	0.533	=	0.6435
B	0.1341	0.148	0.21	0.266		0.1895
C	0.143	0.074	0.105	0.133		0.1058
D	0.083	0.037	0.052	0.066		0.0597
						0.9985

Average of row A= 0.6435, Average of row B= 0.1895, Average of row C= 0.1058, Average of row D= 0.0597.

Weight vector, w = [0.6435, 0.1895, 0.1058, 0.0597]

- Multiply the matrices, initially developed and above written matrix

	A	B	C	D				
A	1	5	6	8	×	0.6435	=	2.7034
B	0.2	1	2	4		0.1895		0.7686
C	0.16	0.50	1	2		0.1058		0.4267
D	0.125	0.25	0.5	1		0.0597		0.2404

- Now, divide resultant matrix as given above with computed weight vector matrix

2.7034	÷	0.6435	=	4.2010
0.7686		0.1895		4.0559
0.4267		0.1058		4.0330
0.2404		0.0597		4.0268

- Finally to check consistency,

C.I = (4.1391-4)/4 = 0.03 From Table 2, for n=4, value of RI=0.90

Now C.I / R.I = 0.03÷0.90=0.0333 <0.10, we conclude that matrix is consistent enough.

Results and Analysis

The ranking of various process parameters/criterions associated with flexible green supply chain, The role of government and various agencies (A), Domestic environmental regulations (B), International environmental agreement (C) and External stakeholders such as suppliers and customers (D) etc. found by AHP method. Analytical Hierarchy process (AHP) shows that the role of government and various agencies has overcalled ranked followed by domestic environmental regulations for the flexible green supply chain driven by environmental pressures. International environmental agreements and the effect of external stakeholders such as suppliers and customers have relatively low ranking. Thus, AHP gives qualitative way of achieving flexibility and green perspective in supply chains considering various environmental pressures.

As weight vector, w = [0.6435, 0.1895, 0.1058, 0.0597]

Figure 4, shows that ranking of parameters/criterion involved for critically assessment of flexible green supply chain driven by environmental pressures is as follows:

Rank 1.The role of government and various agencies.

Rank 2. Domestic environmental regulations.

Rank 3. International environmental agreements.

Rank 4. External stakeholders such as suppliers and customers.

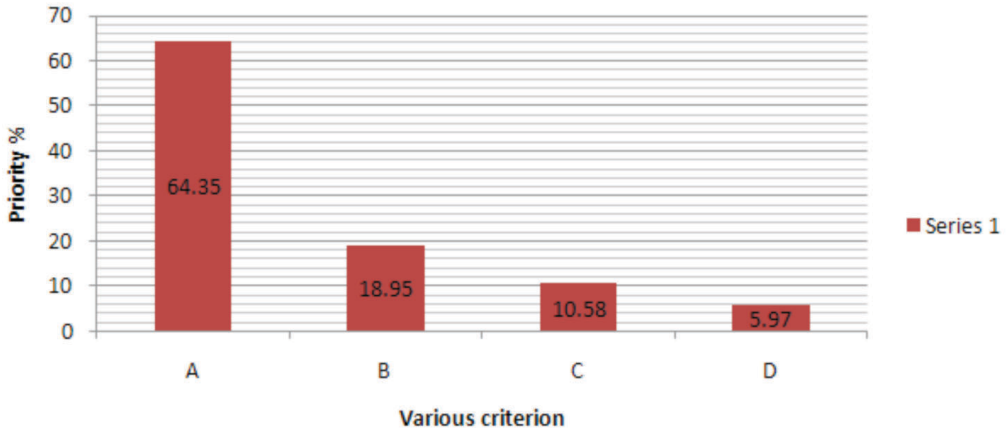

Figure 4: Priority wise effect of various criterions

Discussions and Conclusion

The research shows that the incorporation of flexibility in green supply chain may yield tremendous results. The term "flexibility" in literature is not new in general; it is in its application to green supply chains but still required a lot to do. Supply chain managers also have understood the importance of effective flexible green supply chains to compete in global market and economy. In the 21st century, due to rapid developments in technology and science, changes are not new. Therefore, to handle these creations in business environment there should be equivalent development in supply chain networks**.** But still, certain aspects in supply chain need to improve and developed by looking it from a sustainable flexible green standpoint. It is also found out that the kind of market and particular product are the major indicators for accounting the need of flexibility in supply chains. Further, recommended that a better understanding of using remanufactured/recycled/reusable materials in supply chains will definitely yields sustainable production and operations**.** This study proves to be very beneficial for the learners to understand the need of flexibility and environmental consideration in green supply chains. Briefly, this work may pave a way for green supply chain interaction with various driving environmental pressures and provide a great opportunity for researchers towards its flexibility point of view. Finally, the various managerial implications arising from this study are given as:-

Supply chains known to be solid production process, in which raw materials are changed to final product and then are presented to customers to fulfill their fulfill customer demand, through detailing with resources available through the chain. But, now due to recent developments by applying the concept of flexibility in green supply chain, management is able to adjust strategically in volatile markets, as well as fluctuation from within the chain while considering environmental pressures regulated by various domestic and international agencies. Certain benefits raised from flexible green supply chains can be categorized as short term and long term benefits. Further, the ability of a chain to compensate the changes in demand and managing external

disturbances equally comes under short run benefits. While, handling structural shifts in products development, market behavior and supply channel strategies, generates long run achievements. Summarizing, by knowing the fundamentals of flexibility, operation managers can excellently work within desired objectives to achieve customer satisfaction, market edge, and environmental issue and set up a sustainable green supply chain, without changing it structurally**.**

This work shows the possibilities for more flexibility and its implication benefits in green supply chains. Further work has to provide detailed description about the specific factors that determine, and regulates flexibility in green supply chain driven by environmental pressures. We lot talk about the words market volatility and external disruptions but still required to investigate how a specific market affects flexibility, what are the various external disturbances and how they affect flexible perspective in green supply chains. Moreover, proposed impact wheel diagram to study the problem and used multi criterion decision making (AHP method) to rank the associated criterions, need to be structurally validated and have major limitations of highly dependence on judgments of experts. Therefore, the developed model could be studied and validated by using other advanced decision making tools and this may results some interesting findings while overcoming difficulties in the development of flexible green supply chain.

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