Reducing The Carbon Footprint in the Supply Chain

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Abstract

There has been a lot of human intervention with nature due to industrialisation leading to an increased degradation over time. Hence, Industries across the globe are now trying to reduce their impact by adopting Green Supply Chain management or environment friendly management principles. The world faces the climate change due to global warming because of increase in carbon level in the environment.

The Green Supply Chain approach seeks to minimise a product or service's ecological impact. Therefore this deals with the entire life cycle of the product, since each phase can influence the environment negatively. As a result we have to consider a closed loop model instead of the common linear model of the classical Supply Chain. In the centre of the product life cycle we see the green design. The reason is that industry needs to bear in mind the environmental impact of the future product during the design stage itself. At this early stage itself the organisation needs to trade-off between the investments required and the reduction in the carbon footprint.

This study aims at providing organisations with a framework to capture, measure, monitor, and improve their carbon emissions in the supply chain.

Keywords: Carbon Emissions, Green Supply Chain

1. Introduction

Defining the supply chain is of utmost importance in the context of providing a lowcarbon supply chain. Knowing the length, width and height of the concept of supplychain helps in successfully introducing additional concepts like sustainability, low carbon or green concepts. Many researchers have defined the concept of supplychain in many different ways. Here quite a few important definitions are considered.The term supply chain is defined as the process which integrates coordinates and controls the movement of goods, materials and information from supplier to consumer (Emmett, 2004). The essential point of the supply chain is it links all the activities between suppliers and consumers. The activities in the supply chain are initiated by the final consumer order hence it can also be argued that this process is ademand chain and not supply chain (Emmett, 2004).

It is also defined as the global network of organisations that cooperate to improve the flow of materials and information between suppliers and customers at the lowest cost and at highest speed. The objective of supply chain is customer satisfaction (Govil, et al., 2002). A supply chain is also a network of partners, which collectively convert the basic commodities into final products, which are valued by the customers (Harrison, et al., 2008).

There can be many more of such statements defining the term supply chain but in all the definitions, end customer is of utmost importance for any supply chain. Material flows and information flows are common.A typical supply chain is as shown in figure 1 below.

As can be seem from the figure above there is a central block called Focal firm. Any supply chain can be defined only from one point at a time and this single point is called the Focal firm. The Focal firm is the organisation relative to which all other elements of the supply chain are defined (Slack, et al., 2007). There are millions of organisations in this world and they are interconnected with each other to form a verybig and complex network to produce goods and services, which are valued by the customers/consumers. There is an upstream section and a downstream section. Upstream section is also termed as Buy side and downstream section istermed as Sell side. Upstream section consists of organisations which sell theirproducts to the Focal firm or from the organisations from which the Focal firm buys its input materials. Upstream section is further subdivided into number of tiers. There can be any number of tiers in a supply chain. A first tier supplier is one who sells his goods to the Focal firm. A second tier supplier is one who sells his goods

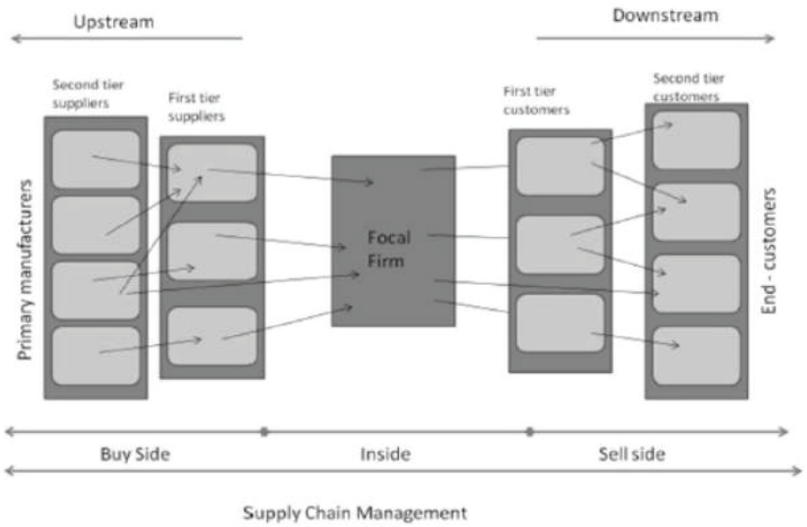

Figure 1 : Typical Supply Chain (Source : Slack et. al , 2007)

to first tier of the Focal firm. And the same continues as farther as the chain is in the upstream section (Slack, et al., 2007). Normally in any automotive industry supply chains, these tiers typically end at third or fourth tier. However, truly applying the supply chain definition as stated by Harrison (2008) the tiers have to be applied up to the basic commodities supplier who mines the earth to obtain themineral.

Further, on the downstream side of the Focal firm are organisations to which the Focal firm sells its products or are the organisations which buy products from the Focal firm. The downstream side is also again classified into many tiers. First tiers are the ones who directly buy the products from the Focal firm. And second tier arethe ones who buy from the first tier. And the same applies throughout the chain until it reaches the end customer (Slack, et al., 2007). Typically in automotive industry the supply chain on the downstream side consists of two or three tiers before reaching the end customer.

Sometimes, as can be seen in the previous figure, Focal firm receives or supplies products to its non first tiers suppliers/ customers also.In any supply chain, material flows from upstream side to downstream side. Information and money flows from downstream side to upstream side.

1.1 Defining Supply Chain Management (SCM)

Supply Chain Management as defined by Council of Supply Chain Management Professionals (CSCMP) *"Supply chain management encompasses the planning andmanagement of all activities involved in sourcing and procurement, conversion, andall logistics management activities." (Blanchard, 2007).*

The SCM includes coordinating and collaborating with channel partners like suppliers, intermediaries (dealers, distributors), third parties (regulatory bodies, government agencies), and customers. In short: Supply chain management integrates supply and demand management within and across companies. (Blanchard, 2007)

2. Supply Chain Integration Model

The aspects that define management of supply chain are

- Purchasing and supply deals with focal firm's immediate suppliers
- Physical distribution deals with the task of distributing products to the first tiercustomers
- Logistics i.e. Management of materials and information flow all along the supply chain

Supply chain management is about how these aspects are understood and utilised for business benefits. The major aspects of supply chain management as summarised by Oliver and Webber (1982) are listed below

- Supply chain is viewed as a single entity
- SCM demands strategic decision making
- SCM needs system integration

System integration to meet the end customer needs is clearly depicted using Beech's (1998) model (refer

figure 2) (Strategic supply chain alignment, 1998). From Beech's (1998) model we can see that integrated systems exudes co-operation, robustness and flexibility. Integrated systems helps in better communication of information. Information flow is the important flow among the material, information and finance flows of the supply chain.

The above model clearly indicates that supply chain management encapsulates every activity {major activities include planning, scheduling, procurement, manufacturing transportation and distribution and warehousing (Frazelle, 2002) in the supply chain that is intended to meet the end customer needs/ demands startingfrom the procurement of basic commodities. This also depicts that decisions in supply chain are strategic and involves the whole construct of the organisation. Any decision at any point in the supply chain will have ripple effect on both upstream and downstream of the supply chain.

3. Performance Measures For Supply Chain

As described in the earlier sections a supply chain is a complex mechanism and to effectively manage such a complex mechanism certain performance indicators are needed. These performance indicators are like state variables for any physical system like a sample in physics experiment whose state variables like pressure, volume and temperature describe the state of the sample at any moment in time. Beamon (1999) says performance measures for a system can be both qualitative andquantitative. Qualitative performance measures are very vague and difficult to utilize.

Hence quantitative performance measures are preferred over qualitative. However sometimes chosen numerical performance measure may not determine the system performance adequately hence a need for a framework which can help select the appropriate performance measure was felt. Various researchers have found number of performance measures and have categorised them(M. Beamon, 1999). Various categories like Cost, Time, Quality and Flexibility were identified (Neely.A et al., 1995). Within each category various specific measures could be identified. However for this method a performance category has to be fixed initially. Further Maskell (1991) argues that the type of performance measure chosen by a manufacturing organisation is directly related to its chosen manufacturing strategy.

He also has cited 2 reasons for maintaining this relationship. They are

1. The company may determine whether its performance meets the company strategy
2. The people in the company focus on what is being measured and hence performance measures will steer the company direction.(Maskell, 1991)

This argument is very well supported by the author using product quality as performance measure. M.Beamon (1999) in his framework has used Resource, Output and Flexibility asthree important performance measure types of strategic goals of an organisation.These three performance measure types are interrelated and have specific goals. They are shown in the figure 2 and the table 1 below :

Table 1 : Performance Measures (Beamon , 1999)

Performance Meaurement type	Goal	Purpose
Resource	High Level of efficiency	Efficient resource mangement is critical to profitability
Output	High level of customerservice	Without acceptable out put customers will not turn to this supply chain again
Flexibility	Ability to respond to changing environment	In an uncertain environment, supply chains must be able to respond to changes

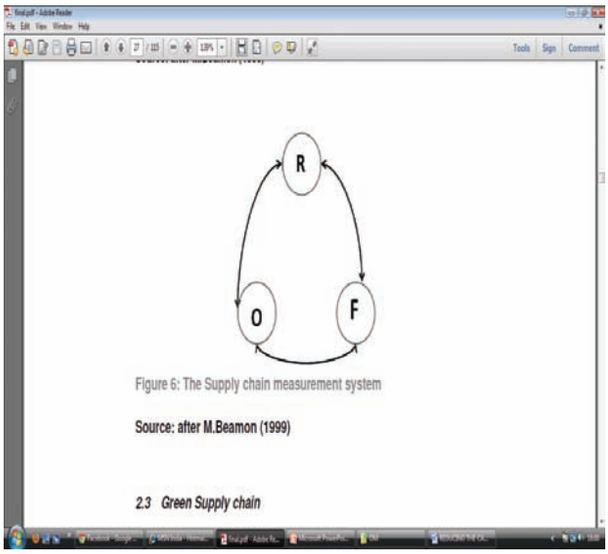

Figure 2: Performance measures (Beamon , 1999)

4. Green Supply Chain Management (GSCM)

"Integrating the environmental thinking & reducing the carbon footprint at every stage of the supply chain "

Figure 3 explains the Green Supply Chain management in detail

4.1 Need for Green Supply Chain Management

In general, the industrial world believed that the green supply chain or sustainable concepts are cost driven and add nothing to the bottom line of the organisations. The need for GSC is triggered by both internal factors and external drivers. Internal factors are supplier issues, environmental attitude etc. External factors are

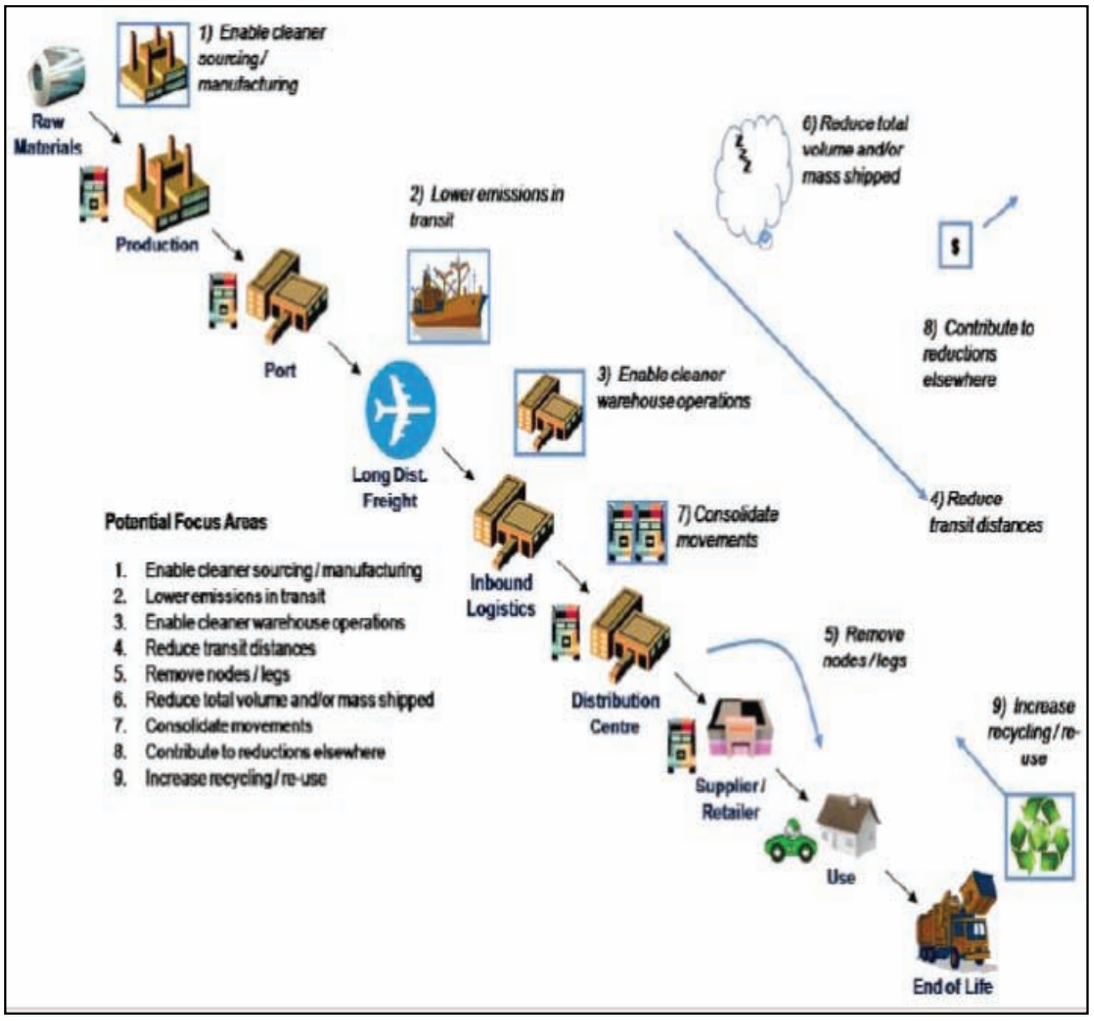

Figure 3: Green Supply Chain Management

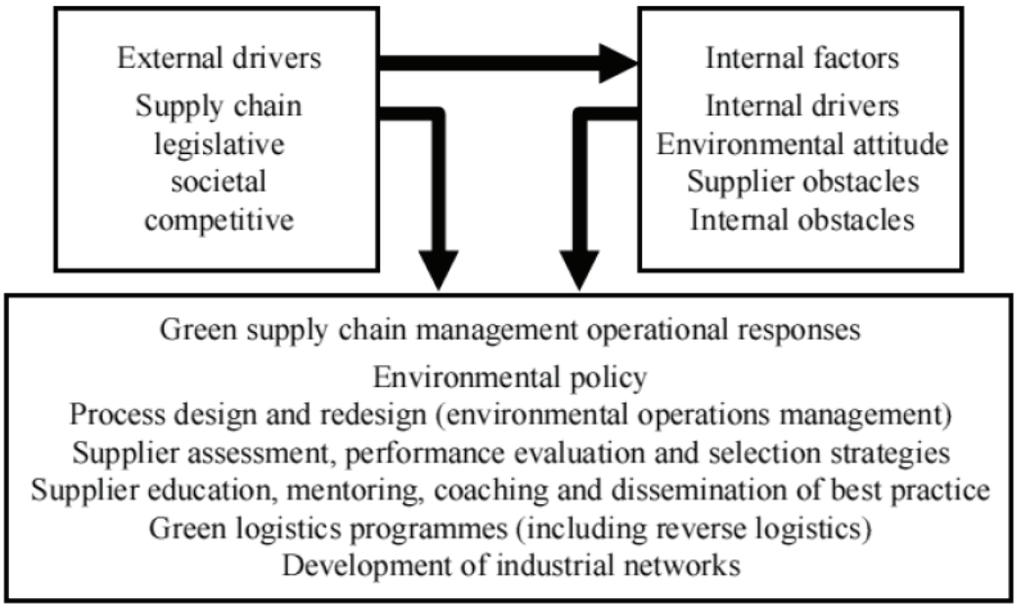

Figure 4: Green Supply Chain Practices

legislations, competition, society etc. argues that green programs from the organisations are results of these internal factors and external drivers. The various green practices adopted by the organisations are a result of inputs (internal factors and external drivers). This is represented by a model shown in figure 4 above.

5. GSCM Pressures & Reponses Model

Nevertheless, modern industries are facing the new challenge to manufacture and produce their goods, which are in harmony with the environment in which they areproduced. The challenge is to develop processes and products, which cansymbiotically co-exist with the environment. This requires accommodating environmental performance into the supply chains of modern industries.

5.1 Beamon's Green Supply Chain Model

M. Beamon (1999) suggests that GSCM is an extension of traditional supply chain. His concept of GSCM is described clearly by the following Figure 5:

According to M.Beamon (1999), the ultimate goal of the extended supply chain is to allow consideration of the immediate and potential environmental impacts due to an organisation's products and processes. The recognition of environmental impacts is right from raw materials to final disposal of the product. The extended supply chain model of M. Beamon (1999) in relation to traditional supply chain model has additional concepts like Recycling, Reuse, and Remanufacturing.Also included in the model is the measurement of waste.

M.Beamon (1999) says *Recycling* is collecting the used products from the field, disassembling the product into child parts, segregating them suitable categories, and processing them to obtain new parts. *Re-manufacturing* is collecting the used product from the field, assessing the condition of the product, and replace the broken,worn out and non-functional parts to make it reusable in its original condition. *Reuse*is collecting the used products from the field and selling them as used products under the organisations brand name.

M. Beamon's (1999) framework of GSCM is to include additional performancemeasures for the traditional Supply chain and monitoring them across the supply chain. He provides a six-step procedure for implementing the Green concepts intothe traditional supply chain.

1. *Identify the process*: This step involves capturing, for each product, theinputs, outputs, by-products and resources needed for conversion of inputsinto desired outputs.
2. *Develop a performance measurement system:* M. Beamon (1999) has suggested a list of performance measures related to environmental issues of a supply chain.
3. *Measure the supply chain system*: In this stage, a composite performance at each step of the supply

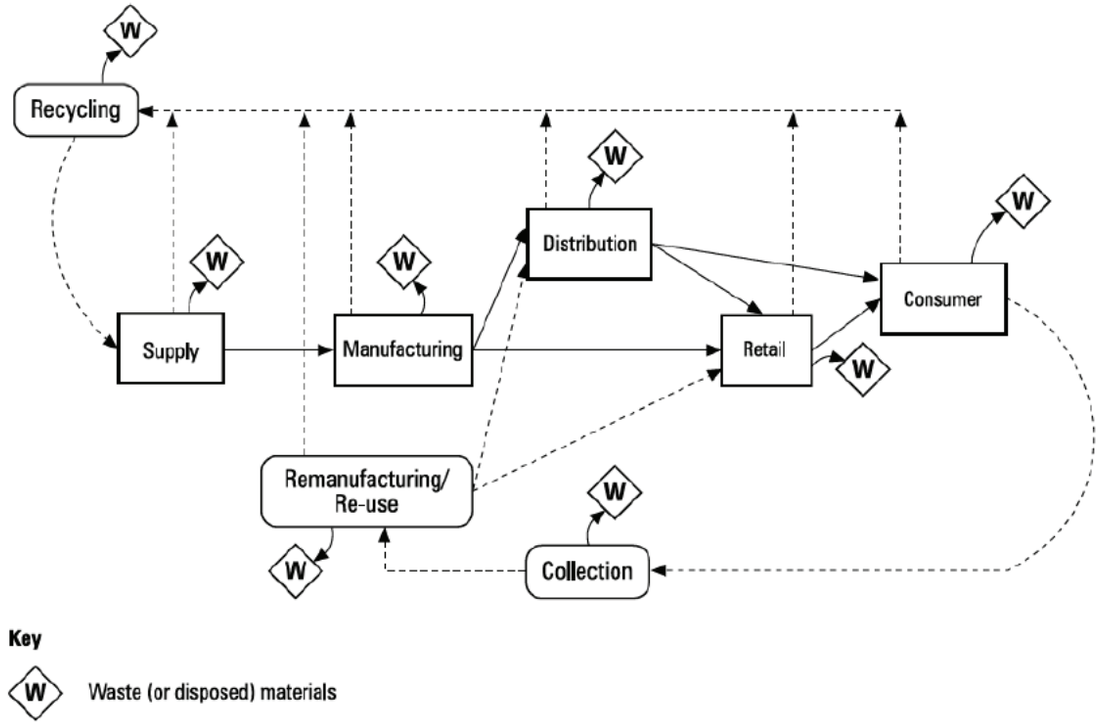

Figure 5: A Green Supply Chain Model

chain is calculated. This composite performance is a function of chosen per

4. *Prioritize*: In this stage, various steps of the supply chain are prioritizedaccording to their composite performance. This helps to concentrate on the least performing step of the supply chain.
5. *Develop alternatives and select approach*: M.Beamon (1999) suggests, in this stage, to select alternatives to worst performing steps of supply chain to improve performance.
6. *Establish auditing and improvement procedures*: This stage involves developing schedules for auditing the supply chain for its performance. This stage should also develop procedures for emergency and noncompliance situations.

This model gives a clear systematic approach to implementing the GSC into a traditional supply chain. It also provides a whole list of performance measures for environmental performance measurement, which can be readily used for developing the performance system. This framework does not talk about the optimum number ofperformance measures to be used for a supply chain. This is needed as the complexity and confusion of the supply chain performance measurement increases; increase in number of performance measures in the supply chain complicates the performance measurement.Further, the framework also does not discuss how to measure the various performance measures listed. What are the roles and responsibilities of the members of the supply chain? Whether same measures can be used in downstream and upstream sections of the supply chain are not addressed by the model. Costs associated with the measurement of these measures, which is an important aspect when it comes to GSC, are also not discussed.

5.2 Shaw and Grant Model Of Performance Indicators

According to Shaw and Grant (2010), selecting the right performance measure is an important aspect for measuring the supply chain performance. This is applicable incase of Green Supply Chain performance measurement also. Environmental performance indicators are divided into three classifications, which aredescribed below.

6. Management Performance Indicators (MPI)

MPI is an indicator, which indicates the management commitment and efforts towards environment. Example: Overall expenditure on environmental costs,Budget

1. Operational Performance Indicator (OPI)

OPI is an indicator which indicates operational environmental performance.Example raw materials used per unit product.

2. Environmental Conditions Indicators (ECI)

ECI is an indicator, which indicates the environmental impact of anorganisation on local, national, and global environment.

Global Reporting Initiative (GRI) was set up by a coalition for environmentally responsible economies to help organisations report environmental economic andsocial performance. GRI has provided two types of performance indicators.

Core indicators: these are the indicators used by most of the organisations and are ofinterest for stakeholders (Shaw and Grant, 2010).

Additional Indicators: these indicators represent leading practice in the economic, environmental and social measurement and provide information of interest tostakeholders and are worthy of considering as core indicators (Shaw and Grant, 2010).

Shaw and Grant (2010) recommend various performance measurement frameworks like Balanced score card, performance prism to adopt the environmental measures into existing Supply Chain performance measurement system. Although balanced scorecard is 15 years old now Shaw and Grant (2010) suggestuse of balanced scorecard for implementing environmental performance measures inthe supply chain. They argue that the balanced scorecard being the most accepted generic performance measurement tool provides a high level of strategic view of corporate performance. Hence, it can be used to report Environmental Supply Chain performance or GSCM. GRI and existing environmental management systems aredesigned specifically for management and reporting of environmental performance.

Hence these two can be combined together to develop a better GSC. They suggest using environmental measures as the fifth element of the scorecard as shown in the figure (Figure 6) below or as part of the remaining four elements as balanced score card accommodates both financial and non-financial measures.

6.1 FALLACY OF THE MODEL

The method of combining the GSC performance measure with the existing performance measure gives this measure a strategic importance in the organisation giving it the most needed management attention.

Although this framework provides a better understanding of the performance measures there is very little guidance on how to select the performance measures.This framework only gives the management direction but does not provide enough details on the implementation part.

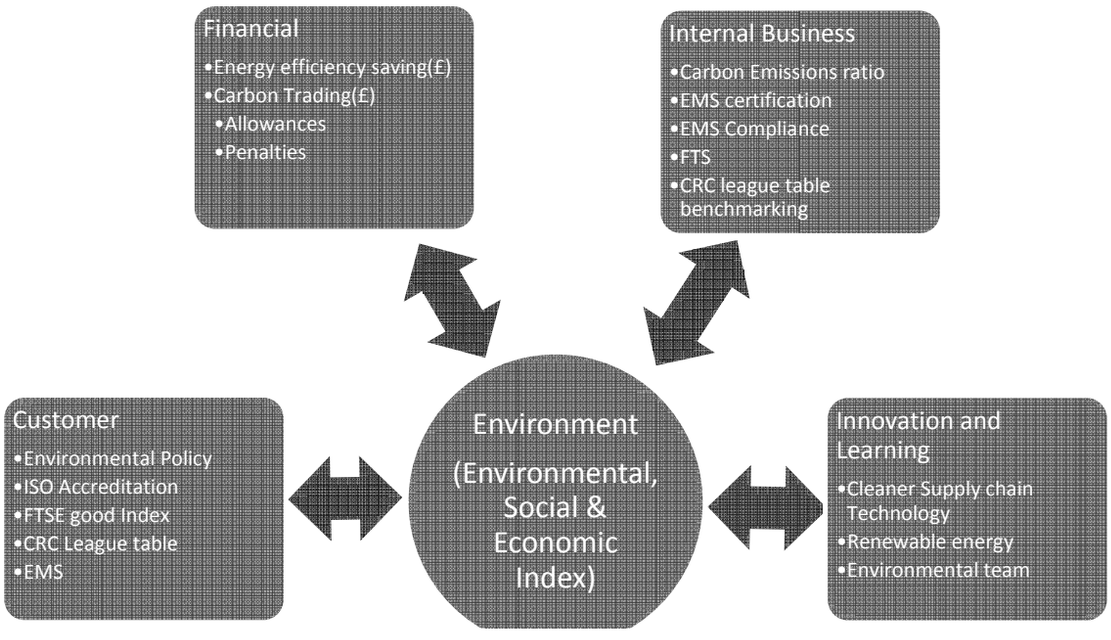

Figure 6: Measurements which could be included in a Balanced Score Card for GSCM

Although various models suggest different indicators, Shaw and Grant (2009) ponder on having only one common measure across the various organisations of the supply chain. They argue that benchmarking is an important organisational process. Having common performance measures across the organisations provide the opportunity to benchmark best in class processes and procedures.

In this regard, Shaw and Grant (2010) stress the importance of having carbon emissions as the single performance measure of Environmental Supply chain. Stressing the importance of the climate change as the biggest environmental problem to which the carbon emissions from the industrial process is the biggest threat having carbon emissions as the single performance measure is more appropriate (Shaw andGrant, 2010). Carbon emissions are an important and a useful measure as they can be measured across all sites of the supply chain of the organisations (Shaw andGrant, 2010).

A carbon emission as classified by ISO 14031 is an OPI and specific emissions from an operation can be measured across the supply chain (Shaw and Grant, 2010). However, specific ECI of carbon emissions cannot be measured as the effect of anthropogenic carbon is global. A limitation of this measure is it does not take into account of the size of the organisation nor the growth of these organisations. This also does not include emissions into water, land, and resource usage. However carbon emissions can indirectly measure the resource usage (Shaw and Grant, 2010).

Carbon emissions do not consider the size of the organisations, is an advantage as a performance measure of entire supply chain because a supply chain might consist of various sized organisations. Having common measure, which is simple, uncomplicated and easy to calculate will solicit co-operation of the entire supplier chain.

7. Carbon as a Single Measure of Performance Indicator

Shaw and Grant (2010) have stressed the importance of using carbon as performance measure of greenness of the supply chain. They also stress theimportance of having less number of performance measures in the supply chain to avoid repetition, confusion, and complexity in Supply Chain performance measurement. M.Beamon (1999) argues that single performance measure may not be sufficient for measuring environmental performance of supply chain. M.Beamon (1999) tries to measure the entire spectrum of environmental impacts due to supply chain and hence a single performance measure may not be sufficient.

However, when a single environmental impact such as climate change is to be measured asingle performance indicator like carbon footprint would be sufficient. Carbon footprint has gained sufficient prominence in today's world as a performance measure. The concept of carbon footprint is very well established. It is a relatively simple concept for understanding. Measurement and documentation is easy. Additionally, using carbon as a single measure implementation of environmental concept into the supply chain will be easier and can lead to financial benefits. Highcarbon footprint of a process is an indication of poor processes and inefficient process. Carbon footprint measurement and further strategizing its reduction leadsto clear financial benefits to the organisations.

8. Carbon Footprint Measurement Technique

Carbon footprints now being one of common measure of environmental performance of a product/process various measurement techniques are available for use. Many organisations like Carbon Trust, Carbon Foundation etc. have contributed towards development of a common method. Every organisation, which has implemented carbon footprint, had its own methods of calculating the carbon footprints for its process/products. This created a need for having standard methodology for calculating the carbon footprint for the products/processes.

This is when British Standards, Carbon Trust and Department of Environment, food and rural affairs came together and created a standard for calculating the carbonfootprint of the goods and services. This standard is known PAS 2050. This standard came into effect from 29th October 2008 (BSI, DEFRA and The CarbonTrust., 2008). This standard is developed based on the Life cycle analysis methodology prescribed by ISO in ISO 14040 and ISO14044.

PAS 2050 clarifies the method of quantifying the carbon footprint in two documents.

1. PAS 2050: How to assess the carbon footprint of goods and services
2. PAS 2050: Specifications for the assessment of the life cycle greenhouse gasemissions of goods and

services.

Former document provides the methodological reference for assessing the carbon footprint in systematic procedure. The systematic procedure involves

1. Building the process maps
2. Checking boundaries and prioritisation
3. Collecting data
4. Calculating the foot print

The later document specifies the requirements for each step mentioned above. This standard clearly helps in establishing the carbon footprint of a process/good.

9. Conclusion

It is evident that carbon footprint is an important variable which will determine the state of damage that industrial production can do to the environment. From the days of the industrial revolution in England to the present the scale and coverage of industrial activities have risen manifold. Use of automation, manufactured equipment, using fossil fuelled resources as well as other forms of energy has led to the generation of industrial wastes on an unprecedented level. These have in turn, contributed to global warming, generation of GHG, the creation of a hole in the ozone layer and so on. All these effects are leading to a situation where the atmosphere of the earth is likely to be damaged beyond repair, subjecting it to the direct rays of the sun in an uncontrollable manner. To prevent these developments, many companies have started actions to reduce their carbon footprint. These is no doubt in an early stage but nevertheless sure to lead to a deceleration in the ever increasing industrialisation. It is incumbent upon all nations and industrial companies to ensure that the carbon emissions are controlled and eliminated to the extent possible through monitoring, technology choices, more R & D to discover more environmentally friendly ways to produce mass produced goods. The Green Supply Chain is here to stay and we should hear about it more in the years to come.

References

Beamon, B. M. (1999). Designing the Green Supply Chain. *Logistics Information Management*, 12(4), pp. 332-342.

Beech, J. (1998). The Supply-Demand Nexus : From Integration to Synchronisation. In Gattorna, J. (ed.), *Strategic Supply Chain Alignment: Best Practices in Supply Chain Management.* Gower, Hampshire, England.

Blanchard, D. (2007). *Supply Chain Management: Best Practices*. John Wiley and Sons.

Oliver, R. K. & Webber, M. D. (1982).Supply-Chain Management: Logistics Catches Up with Strategy. In M Christopher, Chapman Hall (ed.). *Logistics: The Strategic Issues* (pp. 63-75). London: Outlook, Booz, Allen and Hamilton Inc. Reprinted 1992.

Emmett, S. (2004) *Supply Chain in Ninety Minutes*. Management Books.

Frazelle, E. (2002). The Logistics of Supply Chain Management. New York: McGraw Hill.

Govil, M. & Proth, J. M. (2002). *Supply Chain Design and Management - Strategic and Tactical Perspectives*. Academic Press.

Govil, M. & Proth, J. M. (2002). *Supply Chain Design and Management - Strategic and Tactical Perspectives*. Academic Press.

Harrison, A. & Hoek, R. I. V. (2008). *Logistics Management and Strategy: Competing through the Supply Chain* (pp. 316). Financial Times Prentis International.

Maskell, B. H. (1991). *Performance Measurement for World Class Manufacturing*. Portland, OR: Productivity Press.

Neely, A., Gregory, M. & Platts, K. (1995). Performance Measurement System Design. *International Journal of Operations & Production Management*, 15(4), pp. 80-116.

Shaw, S., Grant, D. B. & Mangan, J. (2010). Developing Environmental Supply Chain Performance Measures. *Benchmarking: An International Journal*, 17(3), pp. 320-339.