

A THEORETICAL APPROACH FOR GREEN SUPPLY CHAIN

FEDERAL UNIVERSITY DO RIO GRANDE DO NORTE

INDUSTRIAL ENGINEERING PROGRAM

NATAL (RN) – BRAZIL, January 2004

Breno Torres Santiago Nunes, Bs - Industrial Engineering

Federal University of Rio Grande do Norte – Industrial Engineering Program

PEP/UFRN – P. O. box 1551, Zip code 59078 Natal (RN) – BRAZIL.

Phone: (55) (84) 211 9239. E-mail: breno-nunes@bol.com.br

Sérgio Marques Júnior, Dsc

Federal University of Rio Grande do Norte – Industrial Engineering Program

PEP/UFRN – P.O. box 1551, Zip code 59078 Natal (RN) – BRAZIL.

Phone: (55) (84) 211 9239. E-mail: sergio@ct.ufrn.br

Rubens Eugênio Barreto Ramos, Dsc

Federal University of Rio Grande do Norte – Industrial Engineering Program

PEP/UFRN – P.O. box 1551, Zip code 59078 Natal (RN) – BRAZIL.

Phone: (55) (84) 211 9239. E-mail: rubens@ct.ufrn.br

ABSTRACT

This paper aims to discuss theoretically the Green Supply Chain (GSC) concept, its implementation and prospective benefits by reviewing the current and past literature on the subject. The main issues found in this research are about: basic steps to create the GSC, methods to manage it and the result of its implementation. GSC is usually started by an end producer, which has an environmental management system, and desires to pass good environmental practices to its suppliers. The implementation of GSC can be also done by market requirements. The results include cost reduction, resource conservation, public image improvement, and market competitiveness among others benefits that are describe in this work. Problems for greening the supply chain are the reduction of flexibility of suppliers and the culture of organizations. This paper can help companies meet global market requirements and public administrators to understand the environmental performance through industrial clusters.

Keywords: environmental management systems, supply chain management

INTRODUCTION

Environmental practices are being more acceptable in the world of business. The number of organizations contemplating the integration of environmental practices into their strategic plans and daily operations is continuously increasing (SARKIS, 2003). Due to the increase of environmental impacts from the consuming modern life, issues related to the environment have been increasing their importance among researchers and organizations. According to KHOO *et al* (2001), business organizations are facing increasing pressure of balancing marketing and environmental (green) performance. World market is extremely competitive nowadays and it is more worried about the environment where people live. In the same way of thinking, BEAMON (1999) highlights that the current state and trend of environmental degradation (from regulatory, consumer, and moral standpoints) indicate a need for a change in manufacturing philosophy. EPA researchers corroborate indicating that companies are changing how they manage their supply chains (EPA, 2000).

The new logic on competition is based on supply chains (SCAVARDA & HAMACHER, 2003), and new trends in the market can help to implement green supply chains. There is also the *governance* issue on the supply chain that could facilitate enhancing environmental performance through a supply chain.

The objective of this paper is to describe what is a green supply chain (GSC), how it works, how it is managed and what are the benefits from applying it. The methodology used in this work is based upon a literature review.

THE GREEN SUPPLY CHAIN

According to Sean Gilbert (2001), greening the supply chain is the process of incorporating environmental criteria or concerns into organizational purchasing decisions and long-term relationships with suppliers. Indeed, there are three approaches involved to GSC: environment, strategy and logistics. And, the concept of green productivity (GP) shows that for any development strategy to be sustainable it needs to have a focus on environment, quality, and profitability, which form the triple focus of GP (HWA, 2001).

Working with GSC means to work in the interface of those areas because the GSC is totally linked to environmental protection, which is the main objective of it; strategy because it is formulated long-term decisions and

logistics because it approaches procurement, material handling, distribution, storage, material recovery and disposition.

Figure 1: Approaches of Green Supply Chain



Though some companies did not note the benefits from environmental management systems (EMS); the market will push them to improve their environmental performance. (SARKIS, 2003) says that private organizations such as Hewlett-Packard, IBM, Xerox, and Digital Equipment Corporation have introduced some form of initiative for greening their supply chains including the integration of suppliers, distributors, and reclamation facilities. Organizations are including environmental issues in their negotiation with suppliers to maintain their market share and sometimes to even just to survive (HWA, 2001).

(GILBERT, 2001) supports the idea of two types of categories of initiatives to stimulate the greening supply chain. The first involves improving coordination with supplier on environmental efforts to facilitate the development of greener or more environmentally friendly products. The second type is demanding improved environmental performance at supplier's operating facilities, such as requiring supplier to obtain ISO 14000 certification or achieve a set standard of performance.

Finally, it is very likely that one producer, which one might be the end producer, in a supply chain starts to require better environmental performance

of its suppliers to attend its customer's desires through the supply chain that it is inserted.

The end producer has usually higher profit margin in the supply chain, so it is frequently certified firstly. The other point that indicates the desire of the end producer to start a GSC is because of its direct contact with customers. Other small and medium companies that make part of the supply chain do have only an indirect contact, and then they do suffer less pressure for good environmental performance from public opinion. In the same level, raw material enterprises do not act as early as the end producers.

For (GILBERT, 2001), supply chain greening initiatives have benefits on the level of the individual firm as well as on the national level, because for individual firms, supply chain greening programs bring distinct competitive advantages in terms of lower costs, greener products, and better integration with suppliers. Beyond that, on the national level, greening of supply chain can stimulate markets for green products, while also creating incentives for small and medium sized-enterprises (SMEs) to adopt better environmental practices. In addition to lowering costs, GILBERT (2001) still cites that the GSC can also open new markets for companies.

Problems for greening supply chains are the reduction of flexibility by the use of fewer suppliers and organization's culture. The former is not exactly a GSC problem. It is a market phenomenon to simplify the supply chain management. The latter is more complex because GSC involves the transference of knowledge, technology and environmental practices through the supply chain. It is necessary to choose a supplier and involve it into a program with training and integrate the same (environmental) philosophy in the whole chain.

COMPETITIVENESS, STRATEGY AND GOVERNANCE

(SHIREMAN, 2001) highlights the appearing of the new economy named Eco-Economy, not because it is ecologically sustainable, but rather because the new economy operates much more like an ecosystem than the old, the industrial economy. His analysis is based on the analogy that the eco-economy, having a great amount of ideas and technologies, is as complex, diversified and dynamic as a rainforest, a prairie, a coral reef or any of the complex systems of

nature. He defends that, in this new economy, the new core resource is knowledge because the value of the product is not what it is made of, but how it is designed. In this environment, the complexity is given also by the amount of components in a product, number of suppliers and customers. There is a visible need to manage material and information to assure the standards in terms of quality and environmental performance.

Supply chain management (SCM) brings a new approach to help companies to work in a high-complexity environment. SCM is an integrated philosophy to manage the total flow of a distribution channel from the supplier to the user (JOHANNSON, 1994). SCM is a continuous improvement strategy to understand and manage the supply chain through differentiation based on risk and value (HWA, 2001). For effective implementation of SCM, skilled workers, good processes, vision, and continuous improvement are required (HWA, 2001).

As the competition is based upon supply chain, it is necessary to add value in the chain that wants to compete in a global economy. (HUMPHREY, 2001) expresses that the concept of “governance” is central to the global value chain approach. This term expresses that some firms in the chain set and/or enforce the parameters under which others in the chain operate. A chain without governance would just be a string of market relations.

In automotive industry, the development of new material has emerged as a trend to meet environmental and safety requirements, as noted by (SCAVARDA & HAMACHER, 2003). Lead firms increase complexity when they place new demands on the value chain, such as when they seek just-in-time supply and when they increase product differentiation, however, lead firms also adopt strategies to reduce the complexity of these transactions (GEREFFI *et al*, 2003).

The companies that want to increase product differentiation and reduce complexity in supply chain, usually, tend to rationalize and reduce the number of suppliers. Corporations seek to understand the market, and SCM is a strategic management process with an assessment of the current strengths and weaknesses of the organization and identifies gaps where current performance fails to meet the organization’s vision (HWA, 2001). These market changes helps the implementation of GSC and facilitates Green Supply Chain

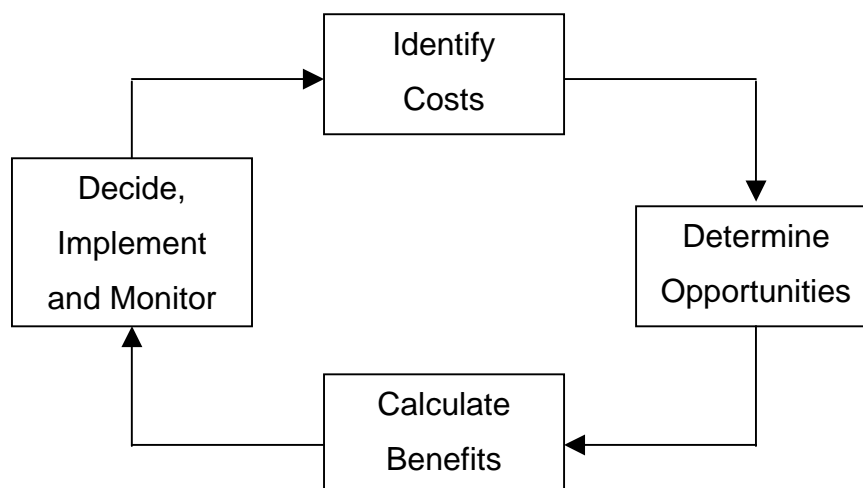
Management, mainly, because of the reduction of number of suppliers, which fact that will simplify the philosophy integration and training programs among the agents of a chain. Governance will make strong companies require from their suppliers good environmental practices and high environmental performance as a strategy to differentiate their product and/or create an environmentally friendly image in the market. Companies have already been increasing their market share by the image of higher environmental performance.

IMPLEMENTING A GREEN SUPPLY CHAIN

There are four basic steps to implement a green supply chain. The following model is a decision-making framework suggested by (EPA, 2000) and it is based upon the best practices of several companies that have successfully initiated and implemented environmental accounting practices. Ideally, companies will customize this approach to best suit their own organizational needs and culture.

The four steps are: (1) Identify costs, (2) Determine Opportunities, (3) Calculate benefits and (4) Decide, Implement and monitor.

Figure 2: Four Basic Steps to implement a Green Supply Chain (EPA, 2000)



In general, the impact of manufacturing operations on the environment may be categorized as follows: waste (all forms), energy use, resource use (material consumption) (BEAMON, 1999). In order to achieve the green supply

chain, organizations must follow the basic principles established by ISO 14001 such as: operation analysis, continuous improvement, measurement, and objectives (BEAMON, 1999).

First Step: Identify Costs

It is essential a systematic review of the facility or process is conducted to determine if and where significant environmental costs occur. The analysis enables the team to later focus where the probability for significant improvement is greatest.

The step 1 can range from the evaluation of specific product or process to an entire corporation. A common Application is at an individual production facility. Key questions proposed by EPA include:

- Are there significant material losses caused by spills or other material handling problems?
- Do ergonomic or other Environment, Health and Safety (EH&S) impacts result from poor or non-reusable packing designs?
- Are substantial quantities of materials discarded because of quality, obsolescence, or inventory problems?
- Can material specification or other easy-to-implement changes reduce suppliers' costs (and subsequently our costs)?
- Are there valuable materials in waste streams that could be salvaged through internal recycling or sold as by-products?

It is also important to say that the structure of traditional cost accounting system usually hides costs and, these “hidden costs” not only hinders a company's efforts to reduce a variety of environmental burdens, but also hinders efforts to improve financial performance. When significant costs are not allocated to the responsible products and processes, this approach may lead to inaccurate costing data and ineffective decision-making. It is necessary to track environmental costs directly to the responsible product, process or facility because if they are hidden in overhead accounts, business decisions are made without sufficient consideration of the potentially costly environmental impacts downstream of the decision (EPA, 2000).

Figure 3: Misallocation of Environmental Costs (EPA, 2000)

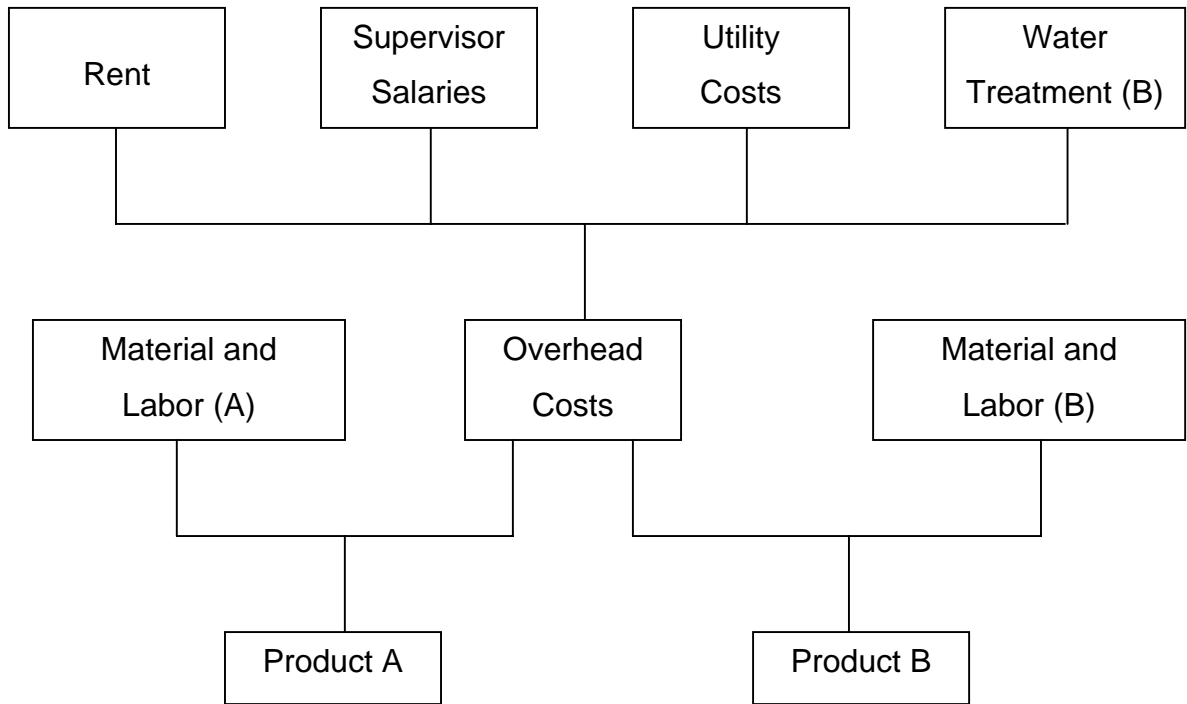
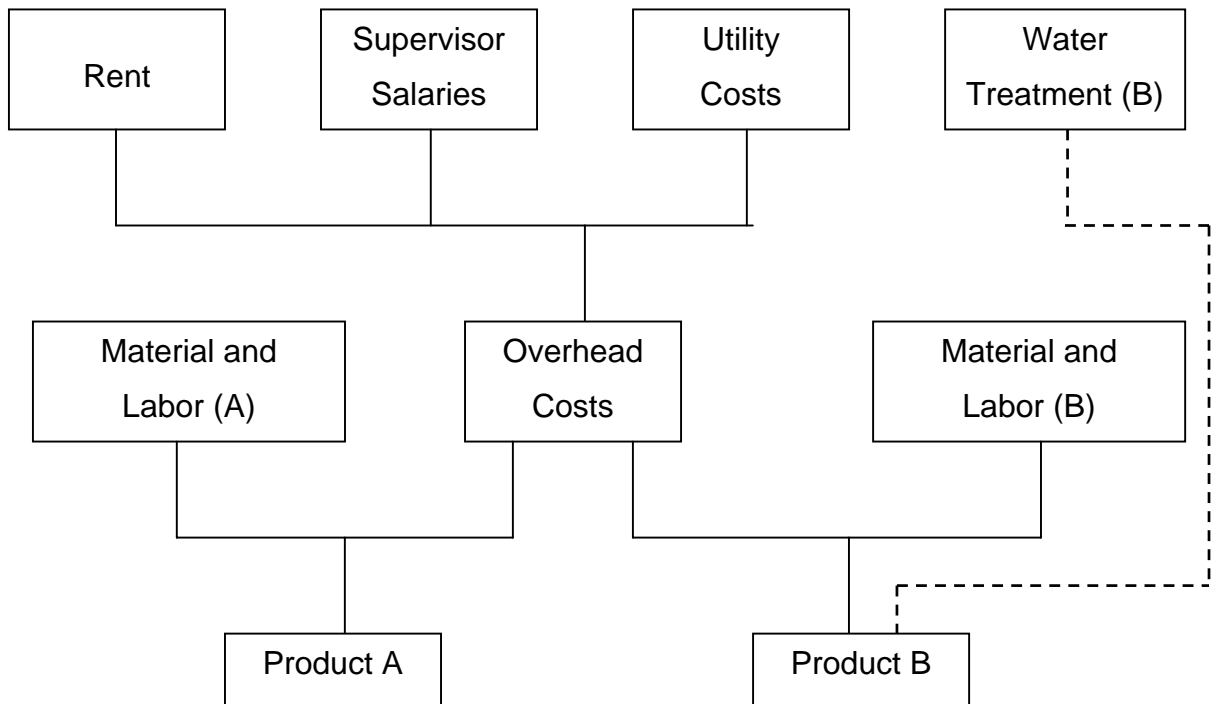


Figure 3: Improved Allocation (EPA, 2000)



This procedure of analyzing the cost structure should be reviewed through the supply chain to identify product or process that has significant costs. In addition, *material tracking* is an assessment of what, where, why and how much material is used, incorporated into products and co products, channeled into waste streams and can help to identify those costs.

Second step: Determine Opportunities

Once a company has completed the initial identification step, the next step is to determine which areas offer the greatest opportunities for improvement and then develop specific solution that reduce costs and negative impacts. According to EPA (2000) many companies have found that the Pareto principle applies, i.e., that a few supply chain improvements provide most of the achievable gains. Thus, the challenge in this step is to discerning high-value opportunities with the limited information that has been collected.

Two procedures that can be used to sort and analyze the activity and cost information obtained in step 1 are to

- Use Pareto diagrams and other bar charts to display environmental costs by supply chain activity and to rank opportunity areas by value;
- Identify root causes of wastes by constructing cause-effect diagrams or by continually asking *why* certain problems or procedures exist.

It is very likely that the solution for the problems become visible after these procedures. There are also other methods for identifying specific solutions such as:

- Interview production personnel to understand potential opportunities for (and barriers to) change;
- Approach suppliers of the key materials and request their support to lower costs and reduce impacts;
- Review the successes of other companies in the same industry.
- Apply the best practices available from trade associations and public institutions.

After the activities were sorted, the next step is “calculate benefits” where the company will select the most viable options for improvement and try to focus on its most significant opportunities.

Third Step: Calculating Benefits

Once a set of high-priority alternatives has been developed, the analytical exercise of calculating the costs and benefits of the various options begins. One approach to the calculation process is to conduct quantitative evaluations, which rely on empirical data, such as: Internal Rate of Return (IRR) and Economic Order Quantity calculations. The IRR is the interest rate at which the net present value (NPV) of the investment is zero. It takes into considerations the amount and timing of the costs, savings, and revenues of the investments. The higher IRR, the better the project. The other option, economic order quantity, reevaluates the lot sizes of purchase orders and production runs as if the company established just-in-time or other lean inventory systems.

A second approach is to conduct qualitative evaluations, which are based on observation and judgment. Through the environmental costs, a team can determine the operational benefits, however, quantification of the costs and benefits may be less straightforward than a qualitative evaluation because of the difficulty of measuring some factors like better image and enhancing employee satisfaction (by switching from a hazardous material to a non-toxic substitute). The recommended approach is to quantify costs when feasible, and then to identify and qualitatively value those other costs that will better inform the decision-making process (EPA, 2000).

Forth Step: Decide, Implement and monitor

Once the financial and environmental improvements have been estimated, the forth and final step is to make a decision implement the changes, and monitor progress.

– Decide

Approaches to decision-making vary significantly among companies. The objective is to select the option that improves both dimensions of performance. Some companies have adopted team decision processes that involve

individuals from several different functions. Other firms have more conventional, unilateral decision processes in which the responsible manager chooses the alternative that he or she believes will be most advantageous. A formal weighing methodology can help decision makers trade off the strengths and weaknesses of one alternative against another.

Regardless of the methodology, the preceding steps provide the financial and no financial information that improves the effectiveness of this effort. The environmental and financial information is considered with a variety of other strategic concerns to enable decision makers to select the best solution for their company.

– *Implement*

After making a decision, the final challenge is implementing the change. Many good ideas are implemented poorly or not at all. In either case, the potential savings and environmental benefits are not realized. To ensure a successful implementation, EPA's (2000) recommendations are:

- Review previous organizational change effort within the company to gain valuable insights on the reasons behind those efforts' successes and failures;
- Establish a group that is solely committed to conducting the cost analyses, implementing the changes, and the ensuring and reporting the successes;
- Conduct one or more pilot studies to demonstrate the benefit of this initiative and gain support for broader implementation;
- Provide appropriate training for employees so that they begin developing the necessary skills.

EPA (2000) highlights that these implementation guidelines are particularly helpful and important during the initial changes, but a company need substantive results to compete against the other initiatives and increase the probability of long-term acceptance and success due to the concurrent companies are pursuing a variety of improvement initiatives at a same time.

– *Monitor*

Completing the methodology, *monitoring* stage is essential to support a critical analysis of the improvements. As in ISO 14000 procedures and following a PDCA (Plan-Do-Check-Act) cycle, a company should periodically monitor its process to ensure continued progress. Additionally, the rapid pace of technological and environmental change necessitates an effort to continuously identify opportunities to further reduce costs and lower potential impacts.

The team should also periodically reviews overall progress toward reducing the wastes and costs identified in the first step. As part of this review, and to improve the accuracy of data, gaps in information and information systems should be analyzed and communicated to those responsible for the development and maintenance of information systems. By monitoring implementation of the cost-reduction efforts, sharing information, and communicating results, supply chain managers can support further gains and justify future improvements.

MANAGING A GREEN SUPPLY CHAIN

This research found several approaches for Green Supply Chain Management (GSCM). No one is sustainable if it is used alone, mainly, when we are considering long-term. Most significant practices are listed below:

- Integrate the philosophy of Reducing, Reusing, Remanufacturing, Recycling and treating disposals (SARKIS, 2003);
- Understand Product Life Cycle: generally, products have five stages during the time (introduction, growth, maturity, saturation and decline) (HILL, 1994). A Supply Chain participants need to deal environmental management decisions to the product stages as noted by (SARKIS, 2003).
- Understand Process Life Cycle: HAYES (1984) shows that usually, the process has four stages (start-up, rapid growth, maturation, commodity or decline). In the same way of product life cycle, it is necessary to provide resources to the EMS according to cost structure and characteristics of each stage;

- Product and Process Life Cycle Assessment and operational life cycle: analyze the operations like procurement, production and distribution. Material tracking has an important role minimize the environmental impacts of those operations. It is also important to be aware of the impacts beyond the manufacturing process, mainly, in the product function (usage) and non-manufacturing sectors like transportation. An efficient reverse logistic system is needed to return the products after their use and incorporate them into a recycling process.
- Explore Information Systems: try to facilitate reporting the information and make it quickly accessible to a wide variety of decision makers as cited by EPA (2000).
- Use simulations systems: time and speed are crucial in today's fast-paced competitive markets, therefore computer simulation is a useful tool offering a wide range of decision scenarios, saving time, energy and money KHOO (2001).
- Continuous improvement by eco-efficiency and, also, eco-effectiveness: Eco-efficiency will make a product better; on the other hand, eco-effectiveness will make a better product (SHIREMAN, 2000). Both of them are simultaneously practices that should be followed to keep enhancing the environmental performance.
- Research and Development (R&D) investments: these investments will promote the creation of new environmental practices and qualify people to improve the current practices.

FINAL CONSIDERATIONS

Most studies have been showing that it is possible to improve both environmental and financial performance. Greening the supply chain has a great importance in this process, due to the influences of the natural environment organizational decisions will not only effect the organization that makes the decision, but its customers and suppliers, as well (SARKIS, 2003).

The issue of organizations incorporating the natural environmental into strategy and operational decisions is a reality that they will or have already encountered (SARKIS, 2003). In this view, work apart of the supply chain will not help a company achieve its goals, instead of this; the recommendation is to transform a relationship between supplier and buyer in a partnership, which has knowledge transference, consistent information flow and integration of philosophies. If the green supply chain is correctly implemented the benefits will become visible either in a short and long term.

EPA (2000) notifies that proactive management of supplier environmental performance, as practiced by Hewlett Packard, can lead to product and process simplification, more efficient resource utilization, product quality improvement, liability avoidance, and an enhanced leadership image. In the case of 3M, eco-efficient manufacturing adoption can lead to more flexible plant configuration, enhanced productivity and strong influence on the evolving regulatory regime. Finally, attention to “end-of-life” product disposition issues, as practiced by Xerox in its photocopier business, can lead to diminished waste liability, reduced cost of material, improved asset utilization, and a strengthened linkage with customers.

We understand sustainability as “*a possible way of living or being in which individuals, firms, governments, and other institutions are responsible for taking care of the future as if it belonged to them today, for equitably sharing the ecological resources on which the survival of human and other species depends, and for assuring that all who live today and in the future will be able to satisfy their needs and human aspiration*” (EHRENFELD, 1999). Simplifying in other words, sustainability is a condition whereby the needs of the present are met without compromising the ability of future generations to meet their own needs (JOHANNSON, 2001).

Work on the area of supply chain greening is still in its early stages, but it is undoubtedly a key piece in the puzzle of sustainability (GILBERT, 2001). Nevertheless, no longer it is acceptable or cost-effective to consider only the local and immediate effects of products and process; it is now imperative to analyze the entire life cycle effects of all products and process. Life cycle analysis of domestic appliances, for example, shows that a majority of total

lifetime energy consumption occurs during use, rather than in product manufacturing or transport (CHANG, 2001).

This work brings directions to implement and manage a green supply chain, however, we need to understand that GSCM involves not only manufacturing process or inside production facilities practices, but also eco-design. The concerns about environment indicate a need to extend supply chain environmental practices to usage and final disposal of the products and change our materialism culture. We must adopt new systems of management and measurement, and a new set of values that see business and the economy as living systems, sustained by profit, performance, and an underlying sense of purpose, long into the future (SHIREMAN, 2001).

ACKNOWLEDGE

The authors would like to thank CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for sponsoring this research.

REFERENCES

BEAMON, B. M. *Designing the Green Supply Chain*. Logistics Information Management. Vol 12. Nº 4, pp 332-342. 1999.

CHANG, L. *Green Productivity: The New Frontier of Sustainable Development*. Greening Supply Chain: Enhancing Competitiveness Through Green Productivity pp 7-14. Tapei, Taiwan. 2001.

EHRENFELD, J. R. *Cultural Structure and the Challenge of Sustainability*. Better Environmental Decisions: Strategies for governments, businesses, and communities. Pp 223-244. Island Press - 1999.

EPA – United States Environmental Protection Agency. *The Lean and Green Supply Chain A practical guide for materials managers and supply chain managers to reduce costs and improve environmental performance*. Washington, D.C., 2000.

GEREFFI, G. HUMPHREY, J. STURGEON, T. *The Governance in Global Value Chains*. Forthcoming in Review of International of Political Economy, 2003.

GILBERT, S. *Greening Supply Chain: Enhancing Competitiveness Through Green Productivity* pp 1-6. Tapei, Taiwan. 2001.

HAYES, R. H. WHEELWRIGTH, S. C. *Restoring Our Competitive Edge: competing through manufacturing*. 1984.

HILL, T. *Manufacturing Strategy: text and cases*. 1994

HUMPHREY, J. SCHMITZ, H. *Governance in Global Value Chains*. ISD Bulletin, vol 32, Nº3, 2001.

HWA, T. J. *Green Productivity and Supply Chain Management*. Greening Supply Chain: Enhancing Competitiveness Through Green Productivity pp 23-28. Tapei, Taiwan. 2001.

JOHANNSON, L. E. *Linking Green Productivity, Green Purchasing and Quality Management Systems: Connections that make waves*. Greening Supply Chain: Enhancing Competitiveness Through Green Productivity pp 29-45. Tapei, Taiwan. 2001.

JOHANNSON, L. *How can a TQEM approach add value to your supply chain?* Journal Total Quality Environmental management, pp. 521-530, 1994.

KHOO, H. H. *et al. Creating a Green Supply Chain*. Greenleaf Publishing pp 71-87. 2001.

SARKIS, J. *A Strategic Decision Framework for Green Supply Chain Management*. Journal of Cleaner Production 11 pp 297-409. 2003.

SCAVARDA, L. F. HAMACHER, S. *Trends in the Automotive Industry's Supply Chain Management*. International Conference on Industrial Engineering and Operations Management pp 51-60. Ouro Preto, 2003.

SHIREMAN, W. K. *The Eco-Economy: Enhancing Productivity and Environmental Performance*. Greening Supply Chain: Enhancing Competitiveness Through Green Productivity pp 15-22. Tapei, Taiwan. 2001.