

Chapter 2

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Abstract

In the following paper is proposed a multi-objective model for components allocation in a Green Supply Chain framework. The model builds on the concept of the supply chain as suggested by Porter, and accounts for the costs of production using the Activity Based Cost accounting method (ABC). Such model is organized in blocks related to several moments in the value chain in a sequential fashion. Above each and every one of these blocks, we included a series of environmental constraints that the firm has to comply, with respect to specific country regulation or in case of a particular corporate policy...

1 Introduction

Global Supply Chain Management (GSCM) is probably one of the most used terms when we talk about how the firms are running their business nowadays. GSCM may be defined as the allocation of goods and services along a series of transnational companies' global network to maximize profits and minimize waste. Inside this very wide concept, we can find the concept of logistics which is in charge of the movement of goods, service and last but not least information from the sourcing of raw material, till it reaches the end customer. Along with these two concepts a third one stuck with them, the concept of Green Supply Chain (GSC). This concept brought to light by a more advanced concern about environmental matters of the developed countries forced the firms to be accountable for their negative externalities related to the environment in which they operate [7].

However such legislations lack from a point of view of legal constraints, setting only a few qualitative restriction, poorly measurable toward enterprises or in some cases letting the customers pay for their environmental behavior toward waste disposition. These facts are inevitably leaving some degrees of freedom to the firms, on the other hand, is also important to notice that these are only seeds of legislation that shows us how the long-term trend will be about the tolerance given to the behavior of firms toward environmental concerns, a trend that in the future may require firms to set particular frameworks to be accountable for their environmental impact.

Because of that we propose a Goal Programming model in order to address such problem, following what proposed by literature we try to enhance such

model fixing quantitative constraints to the pollution generated by the production activity involved in the creation of a good and we also try to implement the benefits of a recycling program enacted by the firm apropos the WEEE directive.

In our case, we chose the networking electronic appliance business (i.e. hub, switch or router). In order to measure such impact, we'll use the framework used by Activity Based Costing in order to assess the marginal environmental impact of any additional unit elaborated by the transnational firms in order to ultimately market the product on its reference market.

2 Green Supply Chain

Green Supply Chain may be defined as the series of interconnected activities across the border of different enterprises that adds value to the goods and services from the sourcing to the market. Whereas Supply Chain Management sets its objective to maximize profits and minimize waste Green Supply Chain sets its objectives even further, posing has its ultimate mission to lower the ecological impact that a firm or a series of them has in their day to day operations. Such operation may involve:

- Green manufacturing and remanufacturing: is the process of controlling and reutilizing of material in the manufacturing in order to limit waste creation[9];
- Green design: is an approach put in place to promote the environmental quality of a certain product or service by reducing negative impacts on the natural environment, an example could be the automatic switch of the television after a period of idleness[2];and
- Green operations in general: by green operation we mean any type of activity which does not fall into the two categories mentioned above but is characterized by a "green" attitude as for example the optimization of the offices consumption thorough a remote-working policy;

It's worth noting that even though CEO and firms' manager are looking for greener supply chain this doesn't mean that such interest was created by an increase in corporate social responsibility but more because of the legislation (in particular the European one) that seemed to be interested in guarantees a certain level of environmental quality to its citizens.

In the market under scope which is the European one there are several legislations concerning the environmental impact of certain e-products. The most important are:

- Waste Electrical & Electronic Equipment (WEEE);
- Restriction on Hazardous Substances (RoHS): ;and
- Ecodesign Requirement for Energy-using Product (EuP): :

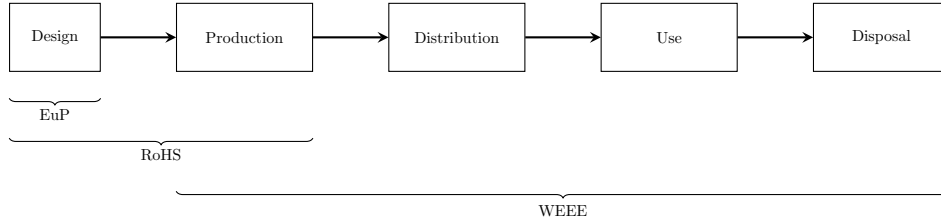


Figure 1: Legislation affection

Such legislation acts at different levels from the sourcing to the costumer involving community member States. The following flow chart illustrates this differences:

In the following subsection, an additional overview is given to such legislation.

2.1 Waste Electrical & Electronic Equipment

The Waste Electrical & Electronic Equipment also called WEEE is ruled in the European Community by Directive 2002/96/EC now repealed by the Directive 2012/19/EU. The objectives of the policy are, to preserve, protect and improve the quality of the environment, to protect human health and to utilize natural resources prudently and rationally. That policy is based on the precautionary principle meaning that the polluter should pay for its damage. Is important to notice that in the European market such directive is impacting all the community members is not perfectly homogeneous ways because of the implementation which is remitted to the local authorities. This problem may incur in potential elusive behavior as highlighted by the German firms who exploited gaps in the law which have allowed them to move large amounts of WEEE declared for recycling to developing economies including India, China, Nigeria and Eastern Europe [5]. Despite such cases, the overall impact of this directive is mostly positive as highlighted by the Eurostat data here exposed.

The WEEE Directive currently sets a minimum collection target of 4 kg per year per inhabitant for WEEE from households. From 2016, the minimum collection rate shall be 45% calculated on the basis of the total weight of WEEE collected. Where the WEEE is calculated with the following formula:

$$W(n) = \sum t = t_{0n} POM \cdot L^p(t, n)$$

Where $W(n)$ refers to the specific quantity of electrical and electronic waste for a specific year, $POM(n)$ is the quantity of new electrical component injected in the market and L is the discard-based lifespan profile for the electrical component injected in the market.

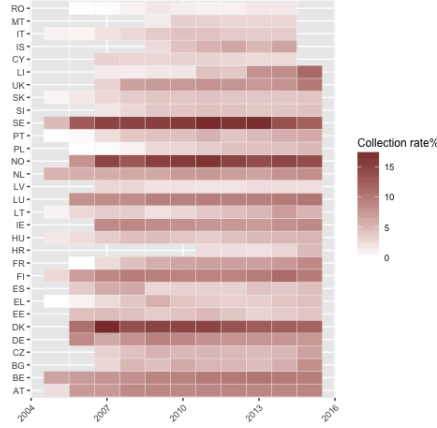


Figure 2: Kilograms of WEEE collected per capita

2.2 Restriction on Hazardous Substances

The Restriction on Hazardous Substances also called RoHS is represented by the Directive 2017/2102 (RoHS 2 recast). The scope is the restriction on the use of certain hazardous substances in electrical and electronic equipment (EEE) such as lead, mercury, cadmium, hexavalent chromium etc... In such case, as opposed to the WEEE the RoHS directive acts as a barrier to the products containing such minerals and not when they become waste. In considering such regulation is worth noting that there are no differences between the dimension of the distributing entity, meaning that small businesses, as well as large businesses, are equally affected by these restrictions. The only amendment is given to the batteries that may exceed such restriction.

2.3 Ecodesign Requirement for Energy-using Product

The Directive 2009/125/EC is meant to deal with Ecodesign regulations, ecodesign regulations require manufacturers to decrease the energy consumption of their products by establishing minimum energy efficiency standards. In particular, The Ecodesign Directive provides a consistent legal framework for improving the environmental performance of products setting out a minimum mandatory requirement for the energy efficiency of these products. In case of the design of IT networking products such as routers and switches the firms are obliged by such directive to implement some ecodesign features such as the maximum wattage of 1W in case of off mode or a standby maximum consumption of 2W. Such measure per se do not impact in any case the supply chain since they are just additional features that has to be implemented in the products sold in Europe.

3 A state of the art review

As posed by the Council of Supply Chain Management Professionals, the supply chain management (SCM) is planning and management of all activities involved in sourcing and procurement, conversion, and logistics as well as coordination and collaboration with the entities. The problem arising from such activities seems to be well addressed by mathematical modelling, other advantages of such approach is the economic sustainability and the possibility to scale the model in order to address different situations. From the comprehensive review built by Muna et al. [4] we discovered the methods used by the academic world, such methods are:

- Linear Programming [3];
- Mixed Integer Linear Programming [6];
- Non Linear Programming [1];
- Multi Objective Programming [8];
- Fuzzy Mathematical Programming;
- Stochastic Programming;
- Heuristics Algorithms and Meta-Heuristics; and
- Hybrid Models.

Is worth noticing how the majority of the models pertain to the category of Mixed Integer Linear Programming, this may be due to the fact that is probably one of the simplest and reliable method that can be used to solve such problems however this simplicity comes with some drawbacks such as the focus on a single linear objective function with linear constraints whereas we may face different objective functions as for example the manager preferences toward greener choices. Another interesting topic brought into light by Auni is that such models are in most of the cases deterministic, where in reality such assumption do not hold most of the time, for example the demand forecast can't be deterministic at all and derives from a stochastic process. This lack of deterministic variable lies also in case of the procurement where the price of a commodity is said to follow, at best, a Geometric Brownian Motion.

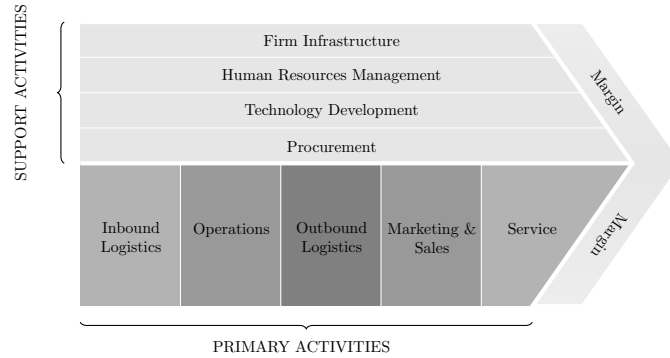


Figure 3: Porter's Value Chain

4 Model formulation

4.1 Data collection

4.2 Objectives

4.3 Constraints

4.4 The Goal Programming model

5 Results and Conclusion

References

- [1] Julian Benjamin. "An Analysis of Inventory and Transportation Costs in a Constrained Network". en. In: *Transportation Science* 23.3 (Aug. 1989), pp. 177–183. ISSN: 0041-1655, 1526-5447. DOI: 10.1287/trsc.23.3.177. URL: <http://pubsonline.informs.org/doi/abs/10.1287/trsc.23.3.177> (visited on 02/08/2018).
- [2] Fabrizio Ceschin and Idil Gaziulusoy. "Evolution of design for sustainability: From product design to design for system innovations and transitions". en. In: *Design Studies* 47 (Nov. 2016), pp. 118–163. ISSN: 0142694X. DOI: 10.1016/j.destud.2016.09.002. URL: <http://linkinghub.elsevier.com/retrieve/pii/S0142694X16300631> (visited on 02/05/2018).
- [3] Hosang Jung, Bongju Jeong, and Chi-Guhn Lee. "An order quantity negotiation model for distributor-driven supply chains". en. In: *International Journal of Production Economics* 111.1 (Jan. 2008), pp. 147–158. ISSN: 09255273. DOI: 10.1016/j.ijpe.2006.12.054. URL: <http://linkinghub.elsevier.com/retrieve/pii/S0925527307000138> (visited on 02/08/2018).

- [4] Josefa Mula et al. “Mathematical programming models for supply chain production and transport planning”. en. In: *European Journal of Operational Research* 204.3 (Aug. 2010), pp. 377–390. ISSN: 03772217. DOI: 10.1016/j.ejor.2009.09.008. URL: <http://linkinghub.elsevier.com/retrieve/pii/S0377221709005694> (visited on 02/08/2018).
- [5] F.O. Ongondo, I.D. Williams, and T.J. Cherrett. “How are WEEE doing? A global review of the management of electrical and electronic wastes”. en. In: *Waste Management* 31.4 (Apr. 2011), pp. 714–730. ISSN: 0956053X. DOI: 10.1016/j.wasman.2010.10.023. URL: <http://linkinghub.elsevier.com/retrieve/pii/S0956053X10005659> (visited on 02/06/2018).
- [6] Frode Riffdfddmo et al. “Optimizing the Norwegian Natural Gas Production and Transport”. en. In: *Interfaces* 39.1 (Feb. 2009), pp. 46–56. ISSN: 0092-2102, 1526-551X. DOI: 10.1287/inte.1080.0414. URL: <http://pubsonline.informs.org/doi/abs/10.1287/inte.1080.0414> (visited on 02/08/2018).
- [7] Samir K. Srivastava. “Green supply-chain management: A state-of-the-art literature review”. en. In: *International Journal of Management Reviews* 9.1 (Mar. 2007), pp. 53–80. ISSN: 1460-8545, 1468-2370. DOI: 10.1111/j.1468-2370.2007.00202.x. URL: <http://doi.wiley.com/10.1111/j.1468-2370.2007.00202.x> (visited on 02/05/2018).
- [8] S.A. Torabi and E. Hassini. “An interactive possibilistic programming approach for multiple objective supply chain master planning”. en. In: *Fuzzy Sets and Systems* 159.2 (Jan. 2008), pp. 193–214. ISSN: 01650114. DOI: 10.1016/j.fss.2007.08.010. URL: <http://linkinghub.elsevier.com/retrieve/pii/S0165011407003739> (visited on 02/08/2018).
- [9] Urvashi, S.R. Singh, and N. Singh. “Green Supply Chain Model with Product Remanufacturing under Volume Flexible Environment”. en. In: *Procedia Technology* 10 (2013), pp. 216–226. ISSN: 22120173. DOI: 10.1016/j.protcy.2013.12.355. URL: <http://linkinghub.elsevier.com/retrieve/pii/S2212017313005094> (visited on 02/05/2018).