How to Measure Relative Efficiency of an Ecodesign

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Abstract

The measure of the effectiveness of a product or production process taking into account environmental and social performances is strongly influenced by the interpretations and goals of different actors (proposers, companies, regulators and affected community). It is difficult to reach a clear consensus. Each actor wants to give a higher weight to those aspects that benefit or affect him-self. This problem is presented when economical actors want to assess and compare the sustainability from products or processes for doing ecodesign and eco-labeling. A Data Envelopment Analysis application is proposed. This tool provides neutral assessment of the effectiveness taking into account the best evaluated products or industries. Social aspects, besides environmental ones, are included in order to evaluate the relative efficiency of comparable products that may not be obtained by using similar processes. The input and output metrics for the model should be identified; then the model will be described. A proposal of a protocol for doing ecolabeling is presented. Finally the advantages and difficulties of this proposal will be discussed.

Key words: Ecodesign, DEA, Impact assessment, Eco-rating Protocol

1. Introduction

Transition to a greener economy requires broad-based greening of products and services. Many eco-labeling schemes, eco-design support tools, and business process standards (such as ISO 14000 and now 26000) have been developed. A transition to a green economy implies to meet sustainable development which claims to take into consideration social, environmental and economic criteria, while developing human activities [1].

But, what really means greening products? More and more companies and costumers try to "green" their development and behavior. The lack of an agreed protocol for eco-design or eco-rating is an impediment to such broad-based greening, for the following reasons: It permits intentional or unintentional "greenwashing" (false or selective claims of "green performance"), it makes eco-design more confusing for companies that wish to do the right thing and in the same way it is confusing to consumers who wish to make green consumption choices. As a result, the "market reward" for truly green products is diminished as is the ability of policy instruments to promote and support green products (and penalize "brown" ones).

Market should punish for example countries where not only environmental impacts are being irreparable but also social impacts. As is it the case of coltan extraction in Congo (material used for cell phones, DVD players, computers, etc) [3] or the case of carbon mines in Colombia which has a significant participation of children in its production chains [2]. Consumer should be aware of this reality. Nevertheless, costumer by his side does not always know what is really "green" or what is meeting social criteria. It will be necessary to find the optimal way to inform consumers about the environmental and social consequences of their behavior and purchases.

Unfortunately, when doing assessment or comparing the sustainability of products, services or processes for doing ecodesign and eco-labeling, it is difficult to get an agreement. Different actors of the economy, such as designers, producers, authorities, consumers, sellers do not have enough tools for judging neutrally if a product or service meets the criteria of sustainability. Currently tools allow different actors to give a certain weight to those aspects that benefit or affect them-self. Some actors for example consider social problems more important than environmental ones. However they are correlated and in many cases the natural resources exploitation does not generate a positive impact in the local population welfare.

Bearing all this in mind, the principal objective of our research is to describe the form of an "ideal" eco-rating protocol that is intended to be objective, neutral, and adaptable to an almost universal range of products and services.

For doing that, authors have examined different studies concerning environmental and social policies, ecodesign, eco-labeling, just fair-trade and have done some observations which will be presented in the state of the art. A mathematical tool which is already used in other sectors, named Data Envelopment Analysis (DEA) [4][5], is proposed as part of a protocol for helping people to compare products and processes and eventually grant a eco-label. One of the advantage of DEA is that it provides neutral assessment of the effectiveness, taking into account best evaluated products or industries. In the same

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way, authors have started a list of aspects that should facilitate qualification of services and products (and indirectly process) as matching or not sustainable development concept. At the end of the paper, we will consider the challenges of implementing such a scheme and real-world evidences it.

2. State of the art

By doing the state of the art concerning ecodesign, ecolabeling, just faire trade, in different kind of documents [6][7][8][9][10][11][12], it is observed principally that:

- Most eco-labeling schemes to date have not provided a balanced treatment of both environmental and social performance. This is a problem, because the two are co-equal aspects of a sustainable economy. In general who cares about environment does not necessarily care about social problems and vice versa. Some products are certified by environmental certifiers and others by fair trade certifiers. Currently producers are asked to take into account ecodesign. European Union for instance, since 2005, has the Directive 2005/32/CE concerning the Ecological Design. But this directive does not say much about the social aspects that every stage of the production should meet (from the cradle to the grave). It will be still necessary to develop a guideline for helping industrial sector to follow and apply policies. It will be compulsory to define at international level what really means “responsible design” or “sustainable design” (which should replace the term ecodesign or ecological design, in order to introduce also social aspects).

- Existing ecodesign’s guidelines [6][7][8][9][10][11] advise only partially about environmental aspects. There is not an extensive international list of goals that producers and designers should tend to match. In some cases reduction on energy consumption is heartily recommended, in other cases only the reduction of CO_2 or of recycled material are suggested. Some guidelines are done by designers who are not necessarily experts on sustainable design. There is poor use of scientific facts. They suggest for example using natural raw materials. But they are not aware that maybe the wood that is going to be used comes from the tropical forest; or they forget that asbestos is a natural material. They even neglect that maybe process for recycling are worse for the environment than incinerating or disposing. These guidelines not always warn about the importance of doing environmental assessment through the life cycle of goods, in order to prevent or mitigate the impacts. Ecodesign’s guidelines do not always treat about informing consumers about the impacts that could not be prevented throughout production chain and distribution.

- Ecolabeling is sometimes driving to a greenwash [13] (false or selective claims of “green performance”), as TerraChoice Association has highlighted in their study called "The Six Sins of Greenwashing" [14]. They have found publicity hide some information. Most messages are not proved, it is claimed “certified” but with no verifiable certification. One of the sins is the vagueness. Products claim to be 100% natural when many naturally-occurring substances are hazardous, like arsenic and formaldehyde. Other sin is the irrelevance. Products claim to be CFC-free, but CFCs were supposed to be banned 20 years ago. Some companies are fibbing. They use logos from international certifiers but they are not really certified.

- There is almost not literature or guidelines that allow authorities, consumers, scientists to compare products. Operations research, particularly DEA, can aid in more objective measures of environmental impact and recently there have been some environmental applications. In 2004, Korhonen et al [15] applied the data envelopment analysis to measure eco-efficiency in 24 power plants in a European country. In 2006 Wu et al [16] use a DEA model for measuring the diffusion of environmentally friendly production EBM in corporations. In 2007 Barba-Gutierrez et al [17] use DEA to measure eco-efficiency in electrical and electronic applications. Meanwhile in 2008, Lozano et al [18] make a proposal for measuring the life cycle by applying DEA. However, in none of above is considered the social aspect. It is until 2009 that the work of White [19] addresses this issue in terms of operations research, but without using DEA.

This situation has made think authors, that it will be necessary to setup an extensive list with recommendations based on scientific data at international level and that it is necessary to establish a standard protocol for comparing products and services.

3. How we propose ecodesign should be

This transformation of materials is the source of many environmental and social problems. In order to reduce those impacts, mankind has two possibilities [27]:

1- to estimate, to prevent; to reduce and to avoid as possible, the environmental and social impact of every human activity that need processing of materials. Greening products and services have to start from the moment of their conception. Greening goods and services have to be throughout their life cycle. It would be crucial that production and consumption locations were closer. This could avoid some transport of materials and their associated but necessary packaging.

2- to reduce the use of material goods: by producing and using only necessary goods and services, for example; by switching from an economy based on principally the offer and demand of material goods to an economy based on a trade of services

[21]; by applying the theory of minimalism as suggested by Bertolini [20]; by assuring a long-term use of material objects. Authors such as J. Généreux and S. Latouche [23] recognize that sustainable development concept has gained importance in recent years. Nevertheless, they criticize the fact that this concept has been applied erroneously: “This concept tries to make us believe that we can continue our development model by only adding a green component” [21] and unfortunately “Our economic model, based on continued expansion, growth for growth, does not consider the finite nature of the planet" [21].

Throughout this research, we have sought to create tools to guide users about their economic, environmental, social and technical decisions. The aim is that decisions about the products and services that they produce, consume or give waste treatment (at the moment products reach the span life) are taken impartially. The idea is to guide the market for choosing the best for current and future generations. Even more, in some cases consumers should decide only to use necessary objects.

Our proposal of responsible or sustainable design is divided into two huge stages:

1- Creation of a protocol that should allow to identify criteria’s who have been taken into account, that allows comparing products and that is intended to lead to an eco-labeling of products, process and services for guiding consumers.
2- Conception of a standard and extensive list of sustainable development aspects that should be considered when designing.

Stage 1: Protocol for getting responsible designs and determining an ecolabel
This stage intends to integrate concepts of eco-design, life cycle analysis, sustainable development (and considering environmental, social and economic) and operations research, specifically a linear programming tool. An important aspect of the proposed protocol is that the user has the option to punish products and processes that are not socially responsible, including indicators to do so from a broad perspective. For example, it is sufficient that just wages be paid and children are not used directly in production plants is punishable by the fact of using coal as fuel from a remote mine in which, if labored children.

We propose a protocol:

1- Establish the set of goods or services which whom will be compared the object that is being studied (from a data base that has to be constructed while this process)
2- Define from the list of environmental and social aspects which items are relevant to be judged and compared. As regards the economic criteria, it is assumed that each actor of the production chain watch that his business is profitable.
3- Application of DEA, a tool which allow qualifying the relative efficiency of every product or service by comparing it with other ways to obtain similar products or services (further information in the following item). In this step, it will be necessary to define the inputs are outputs for the appropriate application of DEA.
4- Allocation of the Ecolabeling (responsible label).

Stage 2: Interactive list of sustainable development aspects
The idea is to propose environmental, economic and social aspects that designers and producers should take in to account throughout the Life Cycle of products and services, in parallel with designing and quality aspects. In the same way, this data will feed, on the future, the data base that will be required for constructing the indicators for applying DEA.

Constructing these lists needs to think about different potential impacts. The lists should be an interactive tool where companies, designer etc could simulate their choices and forecast the associated consequences. In this way, it is expected a first self-control.

Then this tool, more than a list, should be program that gets the aspects, associate with environmental and social impacts and then estimates indicators and finally give relevant information for the next step: DEA and for improving the designs. This tool should then take into account the different interactions between impacts.

4. DEA and ecolabeling

The measurement of efficiency in absolute terms, even for very similar entities, is complex and is affected by subjectivity of different actors, who are involved, in this case in the social and environmental impacts assessment and who may affect weights given to every indicator. Bearing this in mind, in 1978, Charnes, Cooper and Rodes proposed one of the most interesting applications of linear programming: DEA. Although, Farrell had made in 1957 a classic paper on the measurement of efficiency [5], is only in 1978 that this concept was implemented and DEA became a very popular tool for measuring relative efficiency.

DEA considers different types of efficiencies, mainly mix efficiency and radial efficiency. To illustrate the concept behind

DEA, consider the example shown in figure 1, the quantities of inputs x1 and x2 required to obtain a unit of a predetermined product are plotted. The distance that exists from the unit which is evaluated, generically named decision making unit DMU, to the efficient frontier , indicated by the lines A-B-C-D , is a measure of its radial efficiency since if it is contracted until the frontier, it will be produced the same with less input. What is more interesting is that DEA assessed entities create a frontier of efficiency. DEA measures the efficiency (or inefficiency) without allowing the DMU´s to intervene in the weighting average of the factors assigned to each item of evaluation.

There are also points that even belonging to the efficient frontier have inefficiency, even though this is not of the radial type. This case corresponds to the mix inefficiency. In figure 1, the DMU 2 has inefficiency of this type since the quantity of input 1 that it uses can be decreased until the value indicated in point B. La DMU3 has both type of inefficiency: mix and radial, therefore, to make this DMU efficient first it must be contracted until point E and then must be moved to point B.

As a final result DEA provides a efficient score between o and 1 for each DMU (1 corresponds to 100% efficiency), it also shows which peer uncover the inefficiency and which specific item. This is very important since it allows comparing against who is doing things right it is possible to imitate him.

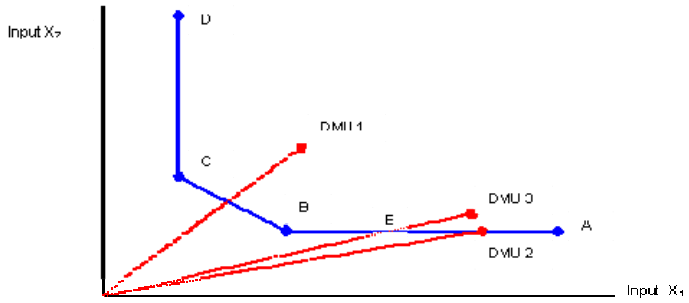

Figure 1. Efficient frontier and type of efficiency [4]

Given the characteristics previously described, DEA is a suitable tool for comparing similar products coming from different producers. In this case of ecodesign it's necessary to define which indicators (social and environmental ones) will be used as inputs and which as output. Once this is established, DEA should be applied and the results must be analyzed. For each producer (DMU) an efficiency score between 0 and 1 will be obtained, as well as information that indicates in which aspect is not efficient and who is doing things better than him. After this step, it will be possible to translate the results into a label (by using figures or colors), showing the social and environmental performance of every enterprise, for guiding consumers.

5. A first proposal of sustainable criteria for construction DEA inputs and outputs

Authors propose a first list of Environmental, Social and Economical aspects.

Environmental aspects

Taking into account the Leopold Matrix [25], lists suggested by Guinee and Svensson [26], by CEPYME Aragon [10], by Knigth [12] and our own experience, we have identified the following list of aspects:

- Quantity of every material (water, fuels and others) and every type of energy required through the chain production
- Quantity of every greenhouse effect gas and energy produced by the process and associated transport (of raw materials, byproducts, intermediate products and the product)
- Quantity of every gas who affects the ozone layer
- Quantity of particulate matter emitted to the atmosphere
- Percentage of renewable resources used (obtained in a responsible way, from a controlled sources)
- Percentage of every contaminant and hazardous materials
- Quantity of sewage spills (affecting surface and groundwater)
- Quantity of every water pollutant
- Quantity of noise associated to the production and service life
- Separability of different parts of the product
- Span life of the product
- Quantity of potential emissions, sewage spills, wastes and consumed energy associated to future waste treatments (of the finished product)
- Kind of respect for ecosystems (flora, fauna)
- The non-use of packaging or the use of sustainable packaging (which seek to comply with other aspects)
- Use appropriate of the industrial urban space

- Historical investments in improving environmental and social aspects throughout the production chain and the future waste, when product reach the end of its span life (in cleaner production, in research, in using ecodesign concepts, in appropriated waste treatment (recycling, incinerating, reusing etc), by implementing ISO 14000, ISO 26000, OHSAS 18000, etc)

Social aspects

- Adequate social protection and safety of company employees, suppliers
- Just wage
- Just work time
- Job stability
- Right to take vacation like in developed countries
- No employment of children under age
- Do not use inputs in manufacturing processes which have involved children.
- Concern for the welfare of the worker's family
- Fair treatment of employees and suppliers
- Employee motivation (clear and transparent policies, recognition, inclusion in decision making, participation in profits,)
- Respect of cultural habits
- Support for improving the quality of life for employees (housing, education and training)
- Equality of gender, race or creed
- Inclusion of all types of workers (with social problems, mental incapacity)
- Economic and social contributions to the welfare for the society
- Compliance with tax payments
- Do not make deals with groups outside the law

Economical aspects

Every actor of the production chain should supervise that after considering environmental and social aspects his business is still profit-earning and competitive. We would like to suggest supervising other economical factors, but it will be difficult that companies give this kind of information.

6. Discussion and conclusion

Possibilities of application

- This tool could be applied to every kind of products and services. It will be necessary to start a data base for having the possibility to compare all kind of products and services.
- Users will have information about not only environmental impacts but also social ones
- The interactive lists of sustainable aspects will allow producers to improve their designs from the moment of conception.
- The proposed protocol will allow companies to improve their goods. Authorities, ONG's and consumers will have more information for taking decisions.
- The results of DEA will allow improving the sustainable label. For doing this, the following aspects should be considered: 1- The DEA score (between 0 and 100%), 2- the types of failures detected (a DMU with a high efficient score might have incurred in a severe fault)
and 3- the commitment to improve the designs.

Difficulties and Limits

- The main difficulty that we have detected is that companies may not always facilitate needed information. They could argue industrial secret. May be only some producers of goods and services should have the willingness of being evaluated and give accurate and timely information
- One part of the tool could be used only by experts; an agreement must be reached regarding how to construct the metrics that is going to be measured.
- If practitioners would like doing assessment, for the first time, for one product or service, it will be necessary to create, in the data base, with ideal products for comparing this first item.
- It is important to keep in mind that obtaining a final version of the protocol for ecolabelling, is a long term commitment.

Strategies and tools for applying the protocol

- Some data could be obtained from results from Leopold Matrix or from inventory step of LCA studies, other data from studies concerning environmental impact assessment.
- Concerning the introduction of ideal products and services, for constructing a data base for comparing it is possible to find the information on national and international regulations.

Perspectives

- Validity test of the proposed method are been performed to make the necessary adjustments. It should be avoided that non achievements, in some aspects, are hidden by the high achievement in others.
- Taking into account the difficulties above-mentioned, the main responsibility relies on the consumers who must assume the commitment of validating the eco-label and force the market so they become a requirement. This requires a big learning process, especially in developing countries in which consumers based their choices in the offer prices.

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