



# A joint implementation of ecological footprint methodology and cost accounting techniques for measuring environmental pressures at the company level

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## ABSTRACT

The aim of this paper is to provide a conceptual framework and a practical methodology for evaluating the environmental pressures associated with company production. The model is based on the joint implementation of the ecological footprint accounting framework and cost accounting techniques. The methodology of cost accounting is applied by companies to determine the monetary cost of their products. These techniques are adopted by business administrations in cases of complex production activities, where the presence of processes with loops and feedbacks, of large infrastructures and multiple outputs make normal cost assignment too simple to correctly quantify the final costs. This paper adapts such monetary techniques to the purpose of measuring not the economic but the environmental costs that are quantified thanks to the adoption of the ecological footprint accounting framework.

To test our model we have applied it to the evaluation of the ecological footprint of the Italian railways: a case study representative of a complex production chain in that it involves the environmental evaluation of a large network utility, characterized by joint production, by multiple outputs and by a great distance between initial environmental costs and final outputs. The results are shown in comparison with a previous analysis on the same subject.

Finally, the paper discusses major potentialities and limits of the joint implementation of ecological footprint methodology and cost accounting techniques.

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## 1. Introduction

The aim of this paper is to provide a conceptual framework and a practical methodology for evaluating environmental pressures associated with company production. The model is based on the joint implementation of the ecological footprint accounting framework and cost accounting techniques. Cost accounting is applied by companies to determine the monetary cost of their products. Our study adapts such monetary techniques for the purpose of measuring not the economic but the environmental costs that are quantified thanks to the adoption of the ecological footprint methodology.

Until now ecological footprint applications for businesses have been fairly limited. Chambers and Lewis (2001) were the first to use such methodology as an aggregated eco-efficiency indicator at the corporate level. They analyzed the case studies of Anglian Water Services (the UK regulated part of the Anglian Water Group) during the years 1998/1999 and Best Foot Forward in 1999/2000. Lenzen et al. (2002) introduced, for the first time, the input–output analysis

to calculate the ecological footprint at the company level, focusing on the case of the Sidney Water Services.

Some studies have adopted ecological footprints to analyze agricultural production: among the earlier ones, Thomassen and de Boer (2005) and Van der Werf et al. (2007) focused on the dairy sector, Deumling et al. (2003) on the horticultural sector and, more recently, Stoeglehner and Narodoslowsky (2009) on the energy-crop sector.

Nicolucci et al. (2008) applied the ecological footprint to compare conventional and organic wine production systems in Italy. In their study, energy and material data are sorted by four production phases (agricultural, winery, packing, distribution) considered separately.

Cerutti et al. (2010) used the ecological footprint for a detailed analysis of a commercial peach orchard. Differently from previous studies, they considered not only the one-year field operations, but also the whole lifetime of the orchard. The calculation was conducted by studying six different orchard stages separately.

A systematic approach, able to analyze also the impacts of supply chains, has been presented by Wiedmann et al. (2009). The model, denominated Hybrid Life-Cycle-Analysis, is based on a combination of a bottom-up approach and a top-down Environmental Input–Output approach. This method provides total

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impact quantification because of its ability to consider both direct impacts, “those occurring within an organization”, and indirect impacts “those generated by an organization’s suppliers or partners” (Wiedmann et al., 2009): in other words such methodology can take into account the impacts embodied in all the purchases of the organization. The model has been applied to small businesses or agencies like the Highlands and Island Enterprise (Censa, 2009), the Waverley Borough Council (Censa, 2008), and the Scottish Parliament (Wiedmann, 2008).

Several authors have outlined the potentialities of the ecological footprint method to become an important tool in measuring industrial metabolism. One of the first and greatest advantages, stressed, among others, in a report by the European Parliament (2001), is its ability to aggregate the environmental pressures into a single unit of measure in a way no other tool can. Ecological footprint has further potential for approaching the issue of sustainability in reference to the overall carrying capacity of the planet (Burdick, 2005) and to be readily and easily understood by all that have an interest in a company’s environmental performance (Barrett and Scott, 2001). Furthermore, the methodology illustrates the progress toward sustainability over time of a single industrial organization (Chambers and Lewis, 2001) as well as constituting an accurate benchmark to evaluate and compare similar companies (Sutcliffe et al., 2005). Finally, it can help the industrial system to adapt to regional/local natural limiting factors (Korhonen, 2003).

In spite of the broad diffusion of the ecological footprint method for territorial applications and its potentialities, until now this methodology has been applied to production in a limited number of analyses, usually regarding case studies characterized by simple production chains (Cerutti et al., 2010; Bagliani and Dansero, 2011).

In our opinion, in order to offer a correct methodology to afford environmental evaluation in case of complex and multi-utility organizations, the environmental accounting system of the ecological footprint needs to be harmonized with other management tools (Holland, 2003). The proposal, discussed in the present paper, is based on a joint implementation of ecological footprint and cost accounting. Section 2 presents the different methodologies: cost accounting, ecological footprint and their joint implementation. Section 3 describes an application of the method to a case study, while Section 4 shows and discusses the results. Conclusions are drawn in Section 5.

## 2. Methods

### 2.1. Cost accounting techniques

Cost accounting techniques have been introduced and adopted by business organizations since 1970 and progressively modified and improved (Culmann, 1973; Peyton Young, 1985; Salvadori and Steedman, 1990). The main aim of these methodologies resides in their capacity to assign economic costs to final output in a correct and coherent way in cases of complex production chains, characterized by joint production, presence of processes with loops and feedbacks and different outputs.

These techniques are useful whenever the productive activities generate not only direct but also indirect economic costs. The former typology of cost refers to those expenditures that can be directly assigned to the final output through a causal and unequivocal relationship. A classic example is the cost to purchase flour in order to produce bread: in this case the baker can directly allocate the money spent for each kilo of flour to the final output represented by the bread produced from that flour. On the contrary, the latter typology of cost regards all the cases when a direct assignment is not possible because of the complexity of the production process. To return to the previous example: there can be indirect

costs if our baker uses the flour to produce not only bread but also several different kinds of biscuits or if he has to buy wood for the oven to bake all products characterized by different cooking times. In both cases it is not possible to directly allocate the cost to the final product: the causal relationship has to be deduced following the whole production chain along all the paths related to the different outputs.

Cost accounting techniques are able to calculate the final costs of a firm production by re-allocating all the inputs costs (including raw materials and other purchased inputs, labor costs and other services, transportation costs and depreciation of capital equipment) to each step of the production chain and, in the end, to final products or services. Thanks to these methodologies a company is able to establish the correct price of its final outputs also in the presence of very complex production lines and large infrastructures and equipment (as in the cases of telecommunications, transport and energy distribution).

Furthermore, cost accounting provides useful information to decision makers about the economic performance of single activities, production lines, operations and services: this is the reason why it is also called management accounting (Hongren et al., 2005). In contrast to financial accounting (which is focused on the overall results including liabilities), management accounting provides detailed reports on the use of single factors of production.

The Activity Based Costing (ABC) methodology used in the present work is an evolution of traditional cost accounting and represents, nowadays, the emerging foundation of cost management (Turney, 2005). It is based on the following considerations, holding true for every economic activity:

- each production process can be divided into single activities, defined as suitable combinations of people, methodologies and the environment, aimed at the provision of a service;
- each activity causes the consumption of different resources and, as a consequence, generates economic costs.

From these principles derives the idea to propose an accounting system based on the concept of activity to aggregate and distribute initial costs along the production chain and, finally, to allocate them to the final products.

ABC methodology prescribes a cost accounting system structured along the following phases.

- (1) Identification of the different activities along the whole production chain. These activities, also called cost centers, represent intermediate cost aggregations useful to follow the causal relationship of production in order to link the initial costs with final outputs. They do not necessary coincide with the organization chart.
- (2) Hierarchical ranking of the cost centers with respect to their causal relationship to final output. In this phase, a helpful distinction is usually made between auxiliary and productive cost centers: the latter refer to those activities related to production, such as manufacturing, marketing and sales while the former relate to those activities supporting the productive ones, such as human resource services, direction and management, research and development.<sup>1</sup>
- (3) Recognition of all the elementary economic costs and their distinction in direct  $DC_i$  and indirect  $C_j$  costs.

<sup>1</sup> Note that the distinction between productive and auxiliary activities adopted by ABC is closely related to the classification in primary and supporting activities proposed in Porter’s studies on value chain (Porter, 1985) but do not necessarily overlap because several primary activities can be classified as auxiliary such as logistics.

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