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Using agro-environmental models to design a sustainable benchmark for the sustainable value method

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ABSTRACT

Farms contribute heavily to overall sustainability. To date, various frameworks, approaches, methods and indicators have been developed to appraise how much corporations (firms, farms) contribute to sustainability. Among these, the Sustainable Value (SV) method helps to determine by which economic entity resources should be used in order to achieve the highest contributions to sustainability, by comparing company's efficiency of capital use against the efficiency of a benchmark. In this work we argue that the SV benchmark does not include certain crucial environmental concepts, such as the carrying capacity of an ecosystem or the multiple vital functions provided by ecosystem services. Thus, it is not a suitable reference for companies to evaluate their contribution to sustainability. As an alternative benchmark to standard SV applications, we propose a farm whose resource use productivity is correlated to the fulfilment of pre-determined environmental constraints: the Environmentally Sustainable Farm (ESF). To design this farm, we created an agro-environmental farm modelling framework that includes: (i) methods and approaches to assess indicators concerning specific environmental issues; (ii) an integrated ecological–economic model based on linear programming. This farm modelling framework is employed to determine both the environmental performance and the economic returns of two farming systems, conventional (CFS) and organic (OFS), which are compared using the Sustainable Value approach. Despite the fact that the OFS environmentally outperforms the CFS, none of them reaches the sustainable performances achieved by the ESF, both performing a negative Sustainable Value. The environmental constraints forced the ESF towards management choices that, although decreasing the economic performance, increase its environmental sustainability behaviour. Hence, the ESF is a viable benchmark that can be used to evaluate farms' environmental sustainability.

1. Introduction

The plethora of definitions of sustainability grasps the relationships between the systems, humans economic, human cultural (social) and physical–ecological (environmental), and emphasize the need to avoid the decline of resources (Costanza and Daly, 1992; Goodland, 1995; Voinov and Farley, 2006). Norton (1992) argues that "sustainability is a relationship between dynamic human economic systems and larger, dynamic, but normally slower-changing ecological systems" underlying that "the effects of human activities remain within bounds so as not to destroy the health and integrity of self-organizing systems that provide the environmental context for these activities" (25).

In the context of agriculture systems, sustainability encompasses the capacity of systems to react and adapt to shocks and stresses (i.e. resilience) continuing over generational time (i.e. persistence) (Pretty, 2008; Robertson and Harwood, 2013). Moreover, sustainable agriculture must infer a "coordinate relationship between humans, organisms, and environment, creating bio-physiologically or ecologically mutual benefits" (Marsden, 2009, 70). Over the long term, it envisages the protection of the ability to farm and produce food into the future, ensuring the availability of options and resources to future generations (Altieri and Nicholls, 2005; Gafsi et al., 2006; Tilman et al., 2002). Within such a context, farms, which are reliant upon nature as a means and condition of production (Marsden, 2009), play a crucial role (Atkinson, 2000). They aim on profit maximization by using and transforming nature (crop and livestock) while holding a strategic position for protecting the environment and its natural resources (Marta-Costa and Silva, 2013). To move towards a sustainable agriculture, society and policy need

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to reward that farmers, as managers of the global and most productive lands on Earth, play a crucial role in meeting the demands to produce food, ensuring at the same time ecosystem services and environmental integrity (Tilman et al., 2002).

The increasing interest to know whether a farm is moving towards or away from sustainability targets has led to the development of numerous methods and approaches (Van Passel and Meul, 2012). In order to measure corporate contributions to sustainability, Figge and Hahn (2004a, 2004b, 2005) formulated a value-oriented approach to impact assessment: the Sustainable Value (henceforth SV). This approach has been widely and, to a certain extent, successfully applied to provide a monetary measure of the contribution to sustainability of firms belonging to the industrial sector (Figge and Hahn, 2005, 2006; Hahn et al., 2010). Based on the concept of opportunity cost, the SV relates the efficiency of capital use by companies to the efficiency of a benchmark in order to determine by which economic entity the resources should be used in order to achieve the highest contributions to sustainability (Figge and Hahn, 2004a). The SV method, however, does not indicate whether the overall resource use is sustainable (Figge and Hahn, 2004a). In fact, the benchmark could be selected in such a way that it does not determine sustainable resource use at all (Ang et al., 2011).

The benchmarking methodology of the SV method has generated an interesting discussion in literature (Mondelaers et al., 2011). Van Passel et al. (2009) combined the SV method with efficiency analysis to benchmark assessment and an updated approach can be found in Hou et al. (2014). Kuosmanen and Kuosmanen (2009) questioned the validity of the SV method by introducing productive efficiency theory. Figge and Hahn (2009) replied that the implementation of productive efficiency theory conflicts with the original financial–economic perspective of the SV method. In our opinion all existing SV benchmarks do not include crucial environmental concepts such as the carrying capacity of an ecosystem or the multiple vital functions exclusively provided by the ecosystem services, which, instead, are key concepts in the definition of sustainability within the agricultural domain.

Our research contributes by designing a new benchmark encompassing prefixed environmental thresholds, i.e. the Environmentally Sustainable Farm (ESF). It represents the level of sustainability to which farms may refer in order to move towards sustainability. Therefore, we implement a farm modelling framework which encompasses: (i) different methods in order to assess the indicators related to local critical environmental issues (e.g. CropSyst and EPRIP); (ii) an integrated ecological–economic linear programming (LP) model to assess the environmental performances and economic returns of farming systems that are then compared in terms of Sustainable Value. Our approach is applied to the sector of dairy farming in Northern Tuscany, Italy. Model results apply to a specific sector (dairy farming) comparing two different farming systems (organic and conventional) in a specific area (Northern Tuscany) due to the fact that the model and its components were calibrated and validated under such conditions. However, the extent and scope of the methods of the modelling framework can be broadened to other farming systems and sectors and pedo-climates, as witnessed by the literature reporting on applications of each single tool used (i.e. CropSyst, EPRIP, LP modelling and SV).

This paper is divided into seven sections. After the Introduction, we briefly describe the SV's theoretical framework in Section 2. In Section 3, we challenge pivotal concepts underlying the definition of the original SV benchmark and we define the Environmentally Sustainable Farm concept. Section 4 describes the farm modelling framework whose implementation allowed us to devise a new benchmark. In Section 5 the ESF is adopted as a benchmark in the Sustainable Value approach and the contribution to environmental sustainability of two farming systems is assessed and compared in terms of land use and environmental performances. Finally, Sections 6 and 7 conclude with a discussion of the research.

2. The sustainable value's theoretical framework

Three different but interrelated decision-making perspectives on the sustainability assessment of resource use exist (Figge et al., 2014): if, how and where resources should be used. The if-question takes the perspective of the victim and aims to assess the negative impact. This burden-oriented approach has received the most attention so far. The how-question refers to the perspective of the resource user and can be analysed on the basis of the production function. The where-question takes the perspective of the beneficiary and can be analysed on the basis of the utility function (Figge et al., 2014). The SV approach can be used to answer the financial–economic question of "where environmental and social resources should be allocated in order to achieve an optimal overall return" (Figge and Hahn, 2009). This value-oriented approach is necessarily complementary with burden-oriented approaches and both need to be considered to arrive at an optimal allocation of resources (Figge and Hahn, 2004b; Van Passel et al., 2007).

The SV measures the corporate contribution to sustainability by assessing and aggregating resource use according to their effect on value creation, rather than their costs and their potential harm (Figge and Hahn, 2004b; Van Passel et al., 2007). To meet this end, a company's resource use is compared with a benchmark, indicating whether the value created by a company exceeds the opportunity cost of its capital use (Figge and Hahn, 2005; Van Passel et al., 2009). Opportunity cost is intended as the yield of an investment with a similar risk and applies to all forms of capital used (Figge and Hahn, 2005).

The authors put together the aforementioned assumptions to create the following formula:

$$SV = 1/R \sum\nolimits_{r=1}^{R} x_{ir} \left[(y_i / x_{ir}) - (y^* / x_r^*) \right] \qquad (1)$$

where SV refers to the sustainable value of the evaluated firm, R stands for the number of resources considered in the evaluation, r for the individual resource (e.g. water, land, energy), y_i and y^* for the value added of the evaluated firm i and the benchmark, respectively, and, finally, x_{ir} and x_r^* stand for the amount of resources used by the evaluated firm i and the benchmark, respectively. More specifically, a company's SV is determined by calculating the following:

1. the corporate efficiency (i.e. value created) for each resource *r* (i.e. the capital form) used by the firm (y_i/x_{ir}), where the use of resources is measured in terms of their environmental impacts, namely the amount of pollutants that the company emits to be able to produce (Figge and Hahn, 2005);
2. the efficiency of the benchmark's resource use (i.e. the opportunity cost) (y^*/x_r^*);
3. the value spread (given by the difference between points 1 and 2, which indicates how much more efficiently a resource is being used in comparison to the benchmark) $[(y_i/x_{ir}) - (y^*/x_r^*)]$;
4. the value contribution (i.e. the value created by the use of a single form of capital in the firm in comparison to the benchmark) x_{ir} $[(y_i/x_{ir}) - (y^*/x_r^*)]$;
5. the SV in monetary terms, obtained by diving the sum of all value contributions by the number of resources considered.

The SV indicates the extent to which a company contributes to make the resource use more sustainable (Figge and Hahn, 2004a, 2005). To achieve this, the efficiency use of the company's resource is compared against the efficiency use of the same resource at the benchmark level, such as a national economy, an industry