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# Environmental efficiency and the impact of regulation in dryland organic vine production

Ana M. Aldanondo-Ochoa[a,*], Valero L. Casasnovas-Oliva[a], Amaia Arandia-Miura[b]

[a] *Universidad Pública de Navarra, Departamento de Gestión de Empresas, Pamplona 31006, Spain*
[b] *Gobierno de Navarra, Servicio de Innovación y Transferencia de Tecnología, Pamplona, Spain*

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ABSTRACT

Organic agriculture figures prominently in the policies adopted by the EU to improve the environmental impact of agriculture. It may also potentially provide other benefits such as high-quality, health-enhancing food products and advancements in rural development. Recent years have brought new research to assess the environmental and economic implications of organic conversion. Economic efficiency comparisons between organic and conventional farms have been extended to include environmental performance. The inclusion of this variable in efficiency analysis may be useful when assessing the potential impact of suggestions to improve environmental regulations and policies. This paper applies the environmental efficiency model to the analysis of different technologies and calculates productivity and efficiency with and without environmental impacts. In the empirical part of the paper Data Envelopment Analysis (DEA) and bootstrap techniques are applied to detect and measure differences between organic and conventional agriculture aggregate efficiency and productivity in a sample of vineyard farms operating in semiarid, non-irrigated conditions in Navarre (Spain), taking farms' nitrogen surplus and pesticide toxicity indicators to consideration. The results for these particular agronomic conditions suggest that organic agriculture is more environmentally efficient than conventional agriculture in dryland farming, in that it achieves a more favorable production to environmental impact ratio. Nevertheless, conversion to organic production methods for extensive vine cultivation under arid conditions does not guarantee substantial environmental gains, since the organic farms in our sample do not display inferior levels of pollution emissions per unit input as extensive conventional production. The overall environmental efficiency of organic farming is largely attributable to the fact that organic farms come closer to the frontier of their own technology. We find no significant technological differences in environmental productivity, however. In terms of policy implications, these findings suggest that the tightening of specific environmental restrictions in organic standards should involve consideration of technological differences in environmental productivity between organic and other alternative technologies. If organic technology is less productive, more restrictive regulation could undermine the economic viability of farms, and thus undermine the other benefits of organic farming. The results also indicate that, at the local level, it could be convenient to address part of organic subsidies to further improvements in the control of pollution from fertilizers and pesticides.



## Introduction

Increasing public concern for the environmental externalities of agricultural production has given organic farming an important role in policies aimed at improving the impact of agriculture on the environment in the European Union.

From the agri-environmental policy perspective, organic agriculture may be considered a voluntary technological standard (OECD, 2010). Organic farming standards (Council Regulation (EC) No 834/2007) prohibit the use of synthetic chemical fertilizers and pesticides, control the use of certain inputs and specify a series of required agricultural practices. Farmers certifying compliance with these standards receive a subsidy per unit of area farmed in exchange for their contribution to public environmental conservation (Offermann et al., 2009; Sauer and Park, 2009).[1] A farmer's compliance with organic farming standards is judged not in terms of environmental performance but in terms of the farmer's

* Corresponding author. Tel.: +34 948 169 633; fax: +34 948 169 404.
*E-mail addresses:* alda@unavarra.es (A.M. Aldanondo-Ochoa), valero.casasnovas@unavarra.es (V.L. Casasnovas-Oliva), amaia.arandia.miura@navarra.es (A. Arandia-Miura).

[1] Subsidies to organic farmers under the EU agri-environmental policy since 1993, have been included in rural development programs and, may increase with the introduction of new grants for organic producers in 2013.

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choice of inputs and technology, which may affect farm economic performance. This raises two major issues potentially affecting EU environmental policy.

The first issue involves the environmental effectiveness of organic farming regulations. Specifically, the question is whether organic standards suffice to reduce the environmental pressure of agriculture or further restrictions are required. This matter is important because both the market and policy-makers consider organic agriculture a more environmentally-friendly food production system. The effectiveness of organic regulation for generating environmental benefits depends on the environmental potential of the organic production system and on how effectively agricultural practices are applied. As far as environmental potential is concerned, various studies based on experimental research show that organic farming may play a key role in environmental conservation and natural resource management (Korsaeth and Eltun, 2000; Pimentel et al., 2005; Thomassen et al., 2008). Additionally, various studies have shown that when it comes to preserving soil quality, and protecting surface water, climate, air and biodiversity, organic agriculture generally performs better than other systems when compared in terms of units of area farmed (Casey and Holden, 2006; Cederberg and Mattsson, 2000; Haas et al., 2001; Hole et al., 2005; Rahmann, 2011; Stolze et al., 2000). Nevertheless, the "conventionalization" hypothesis sustains that organic farming carries the risk of becoming more intensive and industrialized, thereby devaluing its role as a sustainable alternative (Buck et al., 1991; Reed, 2005), and reducing its environmental benefits (Darnhofer et al., 2010). Mansfield (2004) suggests that this conventionalization process may be due to the institutionalization of organic farming, which creates a gap between the complexity of the values and principles underlying the organic movement and the necessary simplification of regulatory measures into a series of prohibited and permitted production practices.[2] Padel et al. (2009) suggest that the environmental concerns raised by the conventionalization hypothesis could be addressed by introducing restrictions on the use of organic and non-organic inputs, and setting explicit objectives aimed at achieving a production system that is more in keeping with environmental quality. This appears to be the direction being taken by the European Union in its regulatory reform program (Padel et al., 2009).

The second issue, which concerns the environmental efficiency of organic farming, arises from uncertainty as to the capacity of organic farming to achieve environmental objectives at a lower cost than is possible with alternative production systems. There are two important sides to this question. Schader (2009), for example, considers that, with a limited budget, it is vital to select agri-environmental policies that can achieve the same purpose at a lower cost. Zimmermann et al. (2011) note, in addition, that agriculture plays various social roles, including not only food production but also the continuation of economic activity in rural areas: hence the importance of checking production system efficiency. Is the maximum output being achieved with the minimum environmental impact? In this respect, various studies have shown that the estimated environmental advantage of organic versus other agricultural production systems diminishes if the comparison is made in terms of environmental impact per unit output. The results of which show it to be superior in some environmental indicators, such as green house emissions, energy consumption and acidification and inferior in others, such as nitrate leaching and eutrophication (Backer et al., 2009; Cederberg and Mattsson, 2000; De Boer, 2003; Tuomisto et al., 2012).

These two issues – the environmental effectiveness of organic regulations and the environmental efficiency of organic agriculture at farm level – provide the focus of this paper. We adopt the approach to firm-level environmental performance evaluation used in the literature on productive efficiency analysis (Dyckhoff and Allen, 2001; Färe et al., 1989; Hailu and Veeman, 2001). This entails comparison of organic and conventional farm performance using multiple environmental indicators[3] to measure differences in output per unit of environmental impact and input (environmental efficiency) and differences in environmental impact per unit input (environmental effectiveness).

With respect to methodological issues, it is worth noting that previous studies (Arandia and Aldanondo-Ochoa, 2008; Kumbhakar et al., 2009; Oude-Lansink et al., 2002) consider organic and conventional agriculture different technologies. Organic farms also support more restrictive environmental regulations. Therefore, when comparing the efficiency of organic and conventional agriculture it is necessary to develop an analytical framework allowing for comparisons between firms that are potentially disparate in terms of the technology they use or the stringency of environmental regulation to which they are subject. The inclusion of the meta-production function (Hayami and Ruttan, 1971) in efficiency analysis provides a basis for the evaluation of firms in different technology groups (Arandia and Aldanondo-Ochoa, 2008; Battese et al., 2004; Kumbhakar et al., 2009; O'Donnell et al., 2008; Oude-Lansink et al., 2002). It allows a decomposition of output in technological productivity differences (technology gap) and efficiency of firms of a group relative to the best practice in this group. At the same time, differences in output for firms under different environmental regulation[4] have been attributed to environmental technical efficiency and to the impact of environmental regulation on productivity (Färe et al., 1989). The impact of environmental regulation is the reduction in output forfeited by farms by using technologies that reduce pollutant emissions. The greater the amount forfeited, the more restrictive the regulation is considered. Then, the impact of regulation on productivity gives an indirect proxy for the regulatory effectiveness.[5] In this paper, we combine these two approaches to propose a decomposition of output into an index of environmental technical efficiency, an index of environmental productivity and an index of the impact of regulation on productivity.

As well as a workable analytical framework, it is also important to select a reliable procedure to measure and compare between-group efficiency. Recently, Simar and Zelenyuk (2007) proposed balanced subsampling bootstrap techniques to compare aggregate output efficiency across industries using individual firm-level data. Individual efficiency scores are computed at an early stage by means of Data Envelopment Analysis (DEA). We chose this method

[2] Guthman (2004) also considers the influence of agribusiness on the setting of agricultural norms and practices in California.

[3] Despite conceptual differences, the terms "environmental externality", "environmental impact", "pollutant emissions", and "environmental pressurewill be used indistinctly throughout this paper, the main point being that agricultural production has an impact on the public environment. For a full clarification of the meanings of these terms, see OECD (2010).

[4] According to Färe et al. (1989) firms have the same technology: the environmentally regulated technology (weak disposability) and the environmentally non-regulated technology (strong disposability). However, they are subject to different levels of environmental regulation given by the current cap on pollutant emissions (per unit input). Regulation on organic agriculture is basically technologically oriented. Only rarely does it restrict the quantity of pollutant emissions, which is what actually determines the value of the environmental effectiveness index. When different groups of firms employ different types of technology, as in the case in hand, the only way to estimate the environmental regulation impact index proposed by Färe et al. (1989) it by constructing a single production set and measuring all firms against the same technological efficiency frontier, which in this case is the meta-frontier of efficiency.

[5] Given the difficulty of aggregating physical quantities of different environmental impacts, we use the impact of regulation index as proxy for the environmental impact per unit input.