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The complex farm-level relationship between environmental performance and productivity: The case of carbon footprint of Lombardy farms

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ABSTRACT

This paper aims to empirically estimate the relationship occurring between farm-level productivity and environmental performance. The productivity performance is measured by the Total Factor Productivity (TFP), while the environmental performance focuses on greenhouse gases (GHG) emissions expressed by the farms' Emission Intensity (EI). The relationship between the two performance indicators is investigated on a panel of Italian (Lombardy) farms observed from 2008 to 2013. The panel specification takes farm heterogeneity into account while the presence of autocorrelation in farm performance due to the typical time-dependence of agricultural production leads to a dynamic panel model estimated via GMM-SYS estimation. Results confirm that a EI-TFP nexus exists but it may significantly differ in direction and magnitude across farm typologies. Policy implications are finally derived.

1. Introduction

The Sustainable Intensification (SI) of agriculture has become a political priority to ensure, at the same time, enough food supply for a growing demand and an efficient and sustainable management of natural resources (FAO, 2011; Foresight Report, 2011). At the global level, the concept of agricultural SI production implies that raising agricultural productivity requires as much attention as increasing environmental sustainability (Garnett et al., 2013). In 2012 the European Union (EU) launched the Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) (European Commission, 2012). EIP-AGRI addresses the key challenge faced by European agriculture in the 21st century: increase food production while conserving natural resources and the environment (Esposti, 2012).

At the farm level, SI is defined by Firbank et al. (2013) as the increasing of agricultural production per unit of input ensuring that environmental pressures generated are minimised. Consequently, SI can be considered as a win-win farm management strategy that assists the balance between environmental sustainability and resource productivity (Gadanakis et al., 2015). From the practical point of view, however, pursuing agricultural SI may be puzzling and controversial.

On the one hand, as stressed by Garnett et al. (2013), a suitable SI strategy is context and location-specific: it is a substantial reframing of food production systems that does not imply “one size fits all” solutions. On the other hand, agricultural sustainability, especially when referred to the farm level, is an elusive concept (Van der Werf and Petit, 2002; Van Cauwenbergh et al., 2007; Sabiha et al., 2016). Rigby et al. (2000: 5) suggested that developing sustainability indicators *‘pulls the discussion of sustainability away from abstract formulations and encourages explicit discussion of the operational meaning of the term*’. A workable approach to assess sustainability at the farm level thus consists in evaluating economic and environmental performances with appropriate indicators.

If it is largely agreed that Total Factor Productivity (TFP) growth represents a suitable measure of productivity improvement also in agriculture (OECD, 2001; European Commission, 2014), expressing sustainability at farm level is much more challenging. First of all because such sustainability is multidimensional and there isn't a consensus on the relevant environmental variables to be considered (OECD, 2001; EEA, 2005; Picazo-Tadeo et al., 2011; Viaggi, 2015).

Among these different environmental pressures caused by agriculture, however, here the focus is on its contribution to global warming, i.e. to greenhouse gases (GHG) emissions, for two major reasons. Firstly, climate change mitigation objectives and the contribution that agriculture is expected to provide, have reached the top of the international (Gerber et al., 2013) and the EU political agenda (European Commission, 2016; Foresight Report, 2011; European Council, 2014). Agriculture contributes to a substantial fraction of global GHG emissions: 24% in 2010 according to the Intergovernmental Panel on Climate Change (IPCC, 2014) or 21% according to Tubiello

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et al. (2015) estimations. In particular, global agricultural GHG emissions are largely and increasingly generated by developing countries and this role poses major issues as limiting emissions may jeopardize agricultural supply and, therefore, food security in those countries. Both at the European and at the global level, therefore, the main concern is how to curb agricultural GHG emissions without affecting productivity.

Secondly, agricultural GHG emissions are themselves the final outcome of a combination of agricultural activities with environmental impacts: intensive livestock, fertilization, land use and management.

This paper aims to assess the nexus between farm-level GHG emissions and productivity in order to derive evidence in favour of-or against- sustainable intensification in agriculture and draw consequent policy implications. As anticipated, whether and how much productivity and environmental performances affect each other is largely an empirical issue mostly because this nexus is arguably heterogeneous across farm typologies. Therefore, a main methodological challenge in carrying out such an investigation is how to take this heterogeneity properly into account.

The rest of the paper is organized as follows. Section 2 reviews the recent empirical literature on the productivity-environment nexus underlying that the use of farm-level instead of aggregate data is novel within this topic and the micro-level approach here adopted thus represents the main value added of the present study. The adopted balanced panel of FADN (Farm Accountancy Data Network) farms of one of the largest Italian regions (Lombardy) observed from year 2008 to 2013 is presented in Section 3 together with the respective farm-level indicators of the productivity (TFP) and the environmental (Emission Intensity, EI) performances. The relationship between the two performances is specified in Section 4 in both the static and the dynamic form and the respective estimation strategies are also discussed. Section 5 presents the estimation results while Section 6 discusses the main results and draws some policy implications. Section 7 finally concludes.

2. The productivity-environment nexus at the micro level: a literature review

Conventional TFP indexes measure productivity gains as more aggregate output produced from a given bundle of inputs (Fuglie, 2012). A major drawback of these conventional TFP measures, however, is that they do not account for non-marketable inputs and outputs. Among these non-marketable goods, agricultural production involves, on the input side, the use or depletion of natural resources and, on the output side, the creation of environmental pressures. Thus, ignoring non-marketable goods in agricultural TFP estimation, might imply systematic biases in productivity calculations and incorrect policy conclusions when only this indicator is considered (OECD, 2014).

Extending the TFP estimation to include these environmental aspects is challenging (Viaggi, 2018). In particular, the scale of analysis becomes crucial as most environmental impacts are highly scale dependent. Therefore, if and to what extent productivity measurement should be corrected depends on the scale of measure. According to Fuglie et al. (2016), the appropriate metric to assess sustainable agricultural productivity growth should have the properties of spatial and temporal variability. If a too large scale is considered (e.g. the national level), significant local variations (for instance regions where unsustainable agricultural activities are prevalent) might be missed. In particular, such aggregation bias can occur because spatial aggregation conceals different, possibly opposite, micro performances in both TFP and environmental indexes calculation.

In order to prevent this bias, recent literature has focused on farm-level analysis (Kimura and Sauer, 2015; Sheng et al., 2015). Micro data allow detecting the heterogeneous nexus between productivity and sustainability across farm typologies eventually generating different performances across space (Cui et al., 2016). Most of these empirical studies, however, concern the whole economy and not specific sectors like agriculture. Cui et al., (2016) analyse the productivity and environmental performance nexus within the whole US economy and find that more productive exporting facilities have significantly lower emission intensity (per value of sales) than non-exporting facilities within the same industry. Similar results of a negative relationship between productivity, export and environmental performance are found by Batrakova and Daves (2012). Also, Forslid et al. (2014) suggest a negative linkage between emission intensity and firm productivity. Barrows and Ollivier (2014) analyse firm-level emission intensity in Indian firms and find that higher market integration may bring about higher productivity but it is ineffective in promoting more sustainable technologies.

However, these conclusions tell very little about the agricultural sector given its strong environmental and productive specificity. Studies on the nexus between productivity and environmental performances using farm-level data are very few and focus on small samples of specific farm typologies (Serra et al., 2014). Sheng et al. (2015) examine cross-farm resource reallocation effects in Australian broadacre agriculture by decomposing aggregate TFP growth and find that resource reallocation between farms due to reforms targeting structural adjustment, has accounted for around half of industry-level productivity growth between 1978 and 2010. Gadanakis et al. (2015) analyse the sustainable intensification of 61 UK arable farms and conclude these farms are quite eco-inefficient.

Some studies have also investigated the role of the support delivered through the Common Agricultural Policy (CAP), particularly via the agri-environmental payments, in influencing farm eco-efficiency. Westbury et al. (2011) evaluate the environmental performance of English arable and livestock farms using FADN data and find that only arable farms participating to agri-environment schemes had a better environmental performance, although responses significantly differ across regions. Picazo-Tadeo et al. (2011) analyse eco-efficiency on a sample of 171 rain-fed Spanish farms. They also find that eco-efficiency is higher for farmers benefiting from agri-environmental programs and with higher-level education.

However, none of the farm-level studies directly assesses whether and how a relationship between productivity and environmental performance occurs and, above all, they usually disregard the wide heterogeneity that may emerge in this respect across different farm typologies.

3. Measuring farm-level performances

3.1. The FADN sample

The sample here considered to reconstruct the farm-level performance indicators, is the constant sample of 362 FADN farms of one Italian region, Lombardy, observed over years 2008–2013 (i.e., 2172 total observations). Lombardy is not only one of the largest Italian region (thus, with a large FADN sample) but its agriculture also presents farms operating in mountainous and flat areas, extensive and intensive production processes and very different production specializations also in terms of GHG emissions (e.g. rice and dairy farms are widely represented). The choice is made to limit the analysis to this single region rather than to the whole Italian FADN sample, because within this limited area the influence on farm performance of major geographical differentials (i.e., the North-South divide) is excluded, while it is still possible to observe large heterogeneity across farm typologies.