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Productivity and environmental costs from intensification of farming. A panel data analysis across EU regions

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ABSTRACT

This paper addresses the need of finding new ways of measuring the environmental and economic consequences of farming. The aim of this study is to inquire into the impacts that excessive intensification has on productivity and environmental costs in the long term and additionally, to explore empirically the trend of these two indicators over time. The contribution of this paper is to perform an empirical study of the trends of productivity and environmental costs of farming in the long-term. To this end, this paper performs a panel data analysis of productivity and environmental costs on a farm accounting database across European regions over the 1989–2009 period. The models proposed take (i) farm output per hectare as indicator of productivity, and (ii) expenditures on energy, pesticides and fertilisers per hectare as proxy indicators of environmental costs. Results provide empirical evidence that the regions under study have a negative trend of productivity and a positive trend of environmental costs over the time frame mentioned. These results correlate negatively with both, economic and environmental sustainability of farms. Arguably, this is aggravated in the latter due to hidden environmental costs valued at zero in traditional accounting.

1. Introduction

Agriculture is facing at the very least, a twofold increasing global pressure. On the one hand, an economic pressure due to an increase in global food demand due to population growth and, on the other hand, an environmental pressure to bring economic performance in line with environmental issues (WHO, 2005). In other words, agricultural sustainability revolves around many interconnected topics including but not limited to food security, food quality, environmental concerns and socio-economic issues. Over recent decades, intensive practices (e.g. economies of scale, use of genetically modified seeds, and reliance on external inputs, irrigation and the substitution of land) brought about significant changes in agricultural production. Although intensive practices have resulted in higher yields in the past (de Ponti et al., 2012), they have also led to an undesirable misuse of common resources (Stern, 2006). Research is still inconclusive whether sustainable or alternative agricultural systems, which tend to have a positive or lesser impact of the environment (Pretty and Bharucha, 2014) are able to substitute prevailing intensive practices at a large scale. The main concern is food security given that comparisons among systems demonstrate higher yields in intensive farms (Cisilino and Madaua, 2007; Lansink et al., 2002).

The traditional defenders of intensive practices claim increasing average yields (FAO, 2008) that hypothetically lead to an increase in economic growth (de Wit, 1992) as the main advantages over alternative agricultural systems. Nevertheless the reliability of these claims in the long term is contentious on both environmental and economic levels.

On the environmental side, there is plenty of scientific evidence which proves that natural resources essential to sustain agriculture are finite (Rockström, 2009). It is impossible to achieve infinite growth counting on finite resources (Schumacher, 1973). Therefore, an impressive growth of yields is doomed in the long run if it is based on a rapid depletion of resources. In this vein, the undeniable improved efficiency and increased average yields due to intensification (de Ponti et al., 2012) might not be sustainable to resource and environmental constrains caused, in some cases, by its very practices (Ruttan, 2002; Tilman et al., 2001). Among the most representative and environmentally harmful practices are the excessive reliance on costly technology, the heavy dependence on non-renewable resources (Batie and Taylor, 1989), the misuse of direct energy inputs mainly in the form of fuels and oils and indirect energy inputs such as pesticides and fertilisers (Tabatabaeefar

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et al., 2009). Specifically, only the misuse of energy, pesticides and fertilisers is proved to cause degradation of soil (OECD, 2001), water pollutant runoff and leaching (OECD, 2012), negative effects on human health (Pimentel and Burgess, 2012; Wilson and Tisdell, 2001), loss of biodiversity (Mondelaers et al., 2009) and even a destructive interference with the nitrogen cycle at a global scale (Gruber and Galloway, 2008).

At the economic level, an intensive high-yield form of agriculture is associated with the law of diminishing marginal returns. This is defined by the amount of an external input and yield which levels off requiring ever increasing external inputs (de Wit, 1992). Furthermore, diminishing marginal returns implies increasing marginal costs and rising average costs. These higher costs correlate negative with the income of farmers and in many cases they can even lead to increasing debt per farm (Anielski et al., 2001). In this sense, increasing costs might endanger the potential of agricultural productivity, which is intrinsically linked to the capability of farmers to pay for required inputs to achieve it (Cerutti et al., 2013).

It is generally accepted that a way of improving environmental and economic performance is to start with accurate measurements (Ajani et al., 2013). The use of indicators has proved useful when there is no direct measurement available (Gaudino et al., 2014). Several complex methodologies that encompass multiple indicators have been designed and applied to farming. These include but are not limited to Life cycle Assessment (ISO, 2006), Ecological Footprint (Rees, 2000), DIALECT (Solagro, 2000), and FarmSmart (Tzilivakis and Lewis, 2004). Additionally, several researchers have actively designed frameworks to identify and value the environmental impacts of agriculture in monetary terms (Pretty et al., 2005, 2000; Tegtmeier and Duffy, 2004). However, no measuring system is globally or even nationally accepted and used in a systematic manner. One specific topic that has not received the attention it deserves is the impact that intensive agriculture has on environmental costs and productivity in the long term in monetary terms. This is particularly important if we consider that monetary values hide impacts valued at zero in traditional accounting. Hence, additional research is needed to enlighten this issue. Therefore, the aim of this study is twofold: (a) to inquire on possible impact of intensification on productivity and environmental costs in the long term and, (b) to explore empirically the trend of these two indicators over time. This paper contributes to the literature performing an empirical study of the trends of productivity and environmental costs of farming in the long-term. To this end, it performs a panel data analysis of productivity and environmental costs on a farm accounting database across European regions over the 1989–2009 period. The models proposed take (i) farm output per hectare as indicator of productivity and (ii) expenditures on energy, pesticides and fertilisers per hectare as proxy indicators of environmental costs.

The remainder of this article is organised as follows: Section 2 discusses the arguments that support our hypotheses of decreasing productivity and increasing environmental costs of intensification of farming in the long-term. Section 3 explains the methodology adopted in this paper to measure the behaviour of environmental costs and productivity over the analysed period. Section 4 presents the results and a discussion of these findings and, finally, Section 5 offers some concluding remarks, while identifying some of the limitations of the study and avenues for further research.

2. Hypotheses development

The notions of increasing productivity and decreasing costs lie at the core of discussions about intensification of farming. It is often understood that the increasing use of external inputs (e.g. energy, pesticides, fertiliser) boost yields and lower costs. Although this is possible in the short-term, in the long-term, excessive intensification might lead exactly to the opposite direction. Systems that allow a turn towards a more sustainable direction may be considered suboptimal in the short run but nonetheless wiser in the long-term (Dietz et al., 2003).

One of the purposes to increase intensification of farming is, arguably, to increase yields; nevertheless a misuse of resources might lead to a decrease in productivity over time. This is due to the fact that farm productivity does not only depend on the amount of external inputs applied but also on the availability of environmental and economic resources.

It has been already stated that “growth has no set limits in terms of population or resource use beyond which lies ecological disaster. Different limits hold for the use of energy, materials, water, and land” (UNWCED, 1987, p. 42). There is evidence that over time, the excess of intensification impacts negatively on the scarcity of natural resources. For example, an unbalanced application of fertilisers degrades the soil over time and exploits the pools of organic nitrogen in the soil (Robertson and Vitousek, 2009). This degradation of soil fertility is also expected to worsen in coming years due to climate change (Colonna et al., 2010). In a similar manner, water scarcity is also arising due to increasing water demand to ensure food security (Rockström, 2009). Although during the green revolution, irrigated lands allowed a substantial increase in yields, water is becoming scarce and will not be possible to increase these irrigated areas (Postel et al., 1996). On the other hand, if one productive resource remains fixed over time, or even worse becomes scarcer, productivity might be negatively impacted by the economic law of diminishing marginal returns. This microeconomic law holds that an additional unit of input (e.g. fertiliser) keeping constant the other input (e.g. land) although will increase marginal product initially, it will decrease and even cause negative marginal product in the long term. At this point adding additional units of the variable factor decreases the output instead of increasing it (Krugman and Wells, 2009, p. 307). This law is particularly important in agriculture where productive land is, without considering soil degradation, constant.

Based on the above discussion our first hypothesis is:

Hypothesis 1. *Output of farming decreases over time*.

Another purpose of increasing intensification of farming is, arguably, to lower costs of production. Nevertheless, an excessive intensification might lead to an undesirable increase of costs in the long term. This is due to the fact, that being intimately related with productivity, costs also depend on environmental and economic factors.

On the environmental side, the fact that natural resources are becoming scarcer also affects the amounts of inputs required to achieve yields. It is proved that intensive farming requires increasing volumes of direct energy mainly for land preparation, irrigation, harvest, post-harvest processing, transportation and increasing volumes of indirect energy mainly in the form of pesticides and fertilisers (Margaris et al., 1996). For example, increasing pesticide doses will boost yields and lower costs in the short-term. However, in the long term it is demonstrated that the volume and number of pesticides required increase due to herbicide-resistant weeds (Heap, 2014).

On the economic side, “productivism” is defined as “a commitment to an intensive, industrially driven and expansionist agriculture with state support based primarily on output and increased productivity.” (Lowe et al., 1993, p. 221). Accordingly, farmers will increase the use of external inputs in order to increase yields despite its environmental impacts. There is evidence of increasing costs of energy-based agro-chemicals such as pesticides and