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Decomposition of energy-related GHG emissions in agriculture over 1995–2008 for European countries

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HIGHLIGHTS

- We decompose agriculture emissions intensity (EI) for some European countries.
- EI is decomposed into five effects: EF, FN, NA, AL and LVA.
- NA and LVA effect have a greater contribution to the variation of EI.
- The use of nitrogen per cultivated area is an important factor of emissions.
- In those countries where labour productivity increases, EI tends to decrease.

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ABSTRACT

The objective of this work is to identify the effects in which the intensity of GHG emissions (EI) in agriculture can be broken down and analysed, as well as their evolution and which of them has more importance in determining the intensity of emissions in agriculture. For that, we used the 'complete decomposition' technique in the 1995–2008 period, for a set of European countries. The change of EI can be decomposed into five effects: (i) the changes in GHG emissions compared to the fossil fuels consumption (EF effect), (ii) the changes in fossil fuels consumption compared to the use of Nitrogen in agriculture (FN effect), (iii) the change in use of Nitrogen in agriculture per ha of utilized agricultural area (NA effect), (iv) the change in utilized agricultural area per worker (AL effect) and the inverse of average labour productivity in agriculture (LVA effect). It is shown that in most countries studied, there was an increase in agriculture emissions intensity, and in only five countries this variable declined. The greatest decrease was seen in Italy (−0.01), while the highest raises were found in the Netherlands (+0.394), Belgium (+0.277) and Luxembourg (+0.203). NA effect and LVA effect were the ones that had a greater contribution to the variation of emissions intensity. In the countries in which the variation of EI is positive, the effect of NA is the main one responsible for this increase (for instance 100%, 118.6% and 104% for Netherlands, Belgium and Luxemburg respectively), which means that the use of Nitrogen per cultivated area is an important factor of emissions. The effect LVA proves to be the most important, specifically in the countries where the change in EI is negative (for instance 113.9% for Italy). This means that in countries where labour productivity increases (LVA decreases), emissions intensity tends to decrease.

1. Introduction

It is widely accepted that the role of agriculture cannot be underestimated in the context of climate change. According to the EEA, agriculture has been responsible, in the last two decades, for about 10% of the total annual emissions of greenhouse gases emitted in Europe. The EU Trading Scheme does not consider the agricultural sector as part of the negotiations of carbon credits,[1] nevertheless countries are concerned about adopting other environmental policies that aim at reducing GHG emissions in the agricultural sector, thereby contributing to the achievement of Kyoto Protocol goals.[2] For the design of a policy of this kind, it is important to understand how the intensity of greenhouse gases (GHGs) emissions (GHG emissions/agricultural value added) has evolved and what factors contribute to the variation of that intensity.

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[1] See European Commission for information about the sectors included in EU Trading Scheme [1].

[2] See OECD [2].

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The objective of this work is to identify the effects in which the intensity of GHG emissions in agriculture can be broken down and analysed, as well as their evolution and which of them has more importance in determining the intensity of emissions in agriculture.

The use of fossil fuels in agricultural machinery and power generation in greenhouses and farms leads to GHG emissions (through CO_2 emissions). We observed that, in general, the GHG emissions in the agricultural sector has suffered a negative change, while the consumption of fossil fuels in agriculture has greatly increased in some countries (such as Belgium and Germany) and significantly decreased in others (such as Sweden and Finland) (see Fig. A1 in Appendix).

However, Nitrogen, an essential nutrient for agricultural productivity, is the cause of most emissions in this sector. Furthermore, it is noteworthy that the intensity of N_2O is 298 times stronger than CO_2 in the greenhouse effect. The use of this nutrient per acreage has been declining for most countries (see Fig. A2 in Appendix), with some exceptions such as Spain, Austria and Slovakia. Belgium and the Netherlands are countries where this ratio was reduced quite significantly.

Therefore we hold that emissions in the agricultural sector are caused primarily by two sources: the use of fossil fuels and the use of Nitrogen. Observing the relationship between these two variables we can see (Fig. A3 in Appendix) this has increased for most countries except for Spain, France, Finland and Sweden. This increase holds up with the decrease in the use of Nitrogen and increased use of fossil fuels, which highlights the bigger importance of fossil fuel pollution caused by the agricultural sector.

The utilized agricultural area also becomes an important variable when studying the emission intensity of agriculture, as countries that face shortage of land tend to increase the use of agrochemicals such as Nitrogen, to augment land productivity. Land abundant countries will tend to increase the cultivated land area by farmer, by using labour-saving inputs, like more machinery. We observed (see Fig. A4 in Appendix) that the countries that increase the ratio area/labour more are Denmark and Sweden and the ones that increase less are Portugal, Spain, Greece, Italy and the Netherlands.

With the exception of Finland and Greece, agricultural labour productivity has increased in many countries (see Fig. A5 in Appendix). This highlights, on the one hand, the increase in total production, and also a reduction in the number of workers in favour of a more mechanized production. This variable (agricultural labour productivity) should be considered as a decomposing factor of agricultural emissions intensity, since the described behaviour may lead to a higher consumption of fossil fuels, by the increase in machinery and by the increase in production, and also to a more intensive use of Nitrogen.

Considering the previous analysis, we decided to use the 'complete decomposition' technique developed by Sun [3] and applied by Zhang et al. [4] to examine agriculture GHG emissions intensity and to decompose it in several effects or components, based on the variables presented above. We considered agriculture emissions intensity for 15 countries as well as its reflecting changes over the 1995–2008 period.

Although there are studies that do this kind of decomposition of CO_2 emissions intensity or of GHG emissions intensity, they focus on the economy as a whole or in particular industries. To our knowledge, there is no literature that applies this decomposition technique specifically to the agriculture sector. In addition, we detected a gap in the literature dealing with the decomposition of the agriculture emission intensity, addressing it in the same way as the intensity of emissions in other sectors, while the agricultural sector has certain specific characteristics. Thus, this study introduces in the decomposition of the intensity of emissions, variables such as the agricultural area, labour productivity and the use of nitrogen as a fertilizer.

The study is divided into five sections including this introduction. In Section 2 we make a brief literature review, in Section 3 we present the data and methodology, in Section 4 the main results and in Section 5 the conclusions.

2. Literature review on decomposition methods

A number of studies in energy economics have examined and used some methods of decomposition of energy consumption, energy intensity (energy/GDP) and/or emissions intensity (emissions/GDP). It is useful to understand the methods of decomposition used to explore the relative contribution of the different factors affecting the changes in these variables. For example, among others, Reither et al. [5], Sun and Malaska [6] and Liaskas et al. [7], considered factors like the level of production, the energy intensity, the fuel mix and the structural effect, the last two being identified as most relevant.

In the particular case of the European Union (EU) and subsets of industrialized countries including EU countries, several studies have investigated the factors behind changes in industrial energy consumption (e.g. Howarth et al. [8]; Greening et al. [9]; Unander et al. [10]) or industrial carbon emissions (e.g. Torvanger [11]; Greening et al. [12]; Liaskas et al. [7]; Schipper et al. [13]).

Recently, Bhattacharyya and Matsumura [14] analysed the reduction in greenhouse gas emissions in 15 countries of the European Union between 1990 and 2007 to find out the contribution of different countries. Using the log-mean Divisia, index decomposition approach, it identifies the driving factors of emissions related to energy and other industrial activities. This important study shows that the emission intensity reduced significantly in both energy-related activities and other processes at the aggregate level, while the performance varied significantly at the individual country level. Changes in the energy mix as well as a reduction in energy intensity and a reduction in the emission intensity from other process related emissions were mainly responsible for the success in the EU-15.

Also, when looking at the sectoral subject, many studies in relevant literature have examined energy intensity and/or emission intensity of the manufacturing sector. We consider the link of studies of industry sectors and sub-sectors relevant. Zhang [15], Zhao et al. [16], Akbostanci et al. [17] and Sheinbaum-Pardo et al. [18], represented earlier studies of energy intensity or CO_2 emissions intensity in industrial sectors *or* sub-sectors. Between energy intensity, the economic activity, the carbon index (emissions per energy), the fuel mix and the structural effect, the energy intensity and the economic activity are the most relevant factors in the decomposition.

To put our study in context, it is important to focus on other studies in literature that study the impacts of structural change on trends in energy use in the agricultural sector. For example, Shyamal and Bhattacharya [19] suggest that, in the Indian agricultural sector, the fuel substitution and abatement technologies for reducing pollution were not present, and shows that the strength of the pollution coefficient component (the ratio of CO_2 emissions and energy use) is relatively low in the sub-periods analysed: 1985–1990 and 1990–1996; the energy intensity component (positive) is also an important factor for increasing CO_2 in the agricultural sector. This positive intensity component indicates that the agricultural sector in India failed to use energy efficiently and that the supply of energy to agricultural sector is highly subsidised.

Zhang et al. [4], found through decomposition analysis, that the economic activity is the biggest factor to influence CO_2 emission in