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Energy consumption across European Union farms: Efficiency in terms of farming output and utilized agricultural area

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ABSTRACT

Energy consumption is a global concern, namely due to the limited availability of energy sources and the consequences in terms of gas emissions, with its implications upon greenhouse gas emissions. In the agricultural sector this question bears an additional concern, considering that it is an economic activity which is sensitive to the dimension of the costs associated with production factors. In this way, the objective of the study presented here is to analyze, the efficiency of energy consumption, for the twelve former European Union countries, at farm level, in terms of farming output and utilized agricultural area, over the period 1989–2009 and for the years 2004–2012, with data available in the Farm Accountancy Data Network. On the other hand, the implications of energy consumption in farms' economic performance were analyzed, through econometric techniques (time series, panel data and generalized method of moments) and models based on the Kaldor developments. As a main conclusion, to stress the decrease in efficiency related with energy consumption by farms in the twelve former European Union countries.

1. Introduction

The quantity of energy consumption from several world countries across different activities is a preoccupation for everyone, considering the energetic resources available, the energy markets, such as those of fossil fuels (and the associated prices), the geolocation of energetic resources and the problems related with energetic self-sufficiency for some countries (many are dependent upon external energy sources).

All these problems have led world countries to search for new energy sources, namely alternative and sustainable sources, and to find more efficient practices across several activities and in their domestic behavior.

In this context, it seems pertinent to study these scenarios for the agricultural sector, namely at farm level, in the twelve former European Union countries. This microeconomic analysis allows us to capture the effects associated with the more typical agricultural systems, such as, for example, the farmers' behavior, in each country, and for all countries. Energy efficiency gains another dimension in the agricultural sector, due to the frequent problematic relationships between the revenues and the costs in farming activities.

Considering the aforementioned, the main objective of this study is to investigate the efficiency of the energy consumed, in farms of the twelve former European Union countries, from 1989 until 2009 and for the period 2004–2012, considering the ratios between energy consumption and farming output and the utilized agricultural area. The statistical information was obtained from the Farm Accountancy Data Network [1]. Two periods were considered, because the first period has the longer time series and the second has more recent data. The data for the two periods cannot be analyzed in a single series, because the methodologies considered by the database for the two series are different. This study will center itself upon the first period (the longer period, which is crucial for time series analysis), because the second period is coincident with the first, with the exception of the three more recent years, 2010, 2011 and 2012. To complement this analysis, several econometric estimations, through time series, panel data and generalized method of moment techniques, and based on the Kaldor [2,3] equation. In this equation the labor growth is dependent on the output growth. This equation has the implicit idea of scales economies (increasing returns to scale, are greater when the coefficient is positive and close to zero) that generate circular and cumulative economic growth processes, considering that greater growths in output, rather than labor, allows for gains of productivity that are the base of the referred cumulative processes. The Kaldor equation was applied to the European farms and extended

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with the energy growth, to analyze the multiplier effect of this variable and to show implications of eventual future interventions in the energy consumed by the farms in each country, considering that the analysis was performed for each of the twelve former European Union countries. Finally few words about the Farm Accountancy Data Network that is a database with statistical information, at farm level, collected through a survey annually implemented in the several member countries of the European Union. The data obtained are processed through a weighing system to obtain representative farms. The remaining part of the study will be divided into literature review, data description and analysis, estimation results and conclusions.

In this context, the research presented here should prove to be a fundamental novelty for the international scientific community and for the operators related with the energy and agricultural sectors. Indeed, this study, considering the literature consulted, is an original study that analyses the framework for energy consumption, at farm level, for the twelve former European Union countries, in terms of efficiency and in terms of multiplier effects at a microeconomic level, taking into account the data used and the model considered as a base. This investigation will provide the different operators with a better understanding of the dynamics within the European representative farms, as well the contribution of energy consumption toward these performances. In general, these kinds of analysis are made at a macroeconomic level, where the dynamics at farm level are forgotten. On the other hand, the econometric methodologies and the several statistical tests used allow for greater robustness in the results and conclusions made in this contribution. In fact, the Eurostat Statistics Explained [4] stress the importance of the analysis of energy use in agriculture and the data at farm level, providing interesting statistical information, considering the heterogeneity of the agricultural sector in the European Union countries.

2. Literature survey

The following is a literature review, which will allow us analyze the existing literature and support the options, conclusions and decisions adopted in this study.

The improvements in agricultural labor productivity may decrease the needs for energy and other factors of production [5]. In fact, in Dutch dairy farms, greater labor productivity is accompanied by low energy use [6]. In turn, the utilization of nitrogen in agriculture contributes more towards greenhouse gas emissions, than fossil fuels [7]. These conclusions suggest that there is much potential to reduce the energy consumed by the agricultural sector that will have a greater impact on cost reduction rather than, for example, on greenhouse gas emissions.

Indeed, the reduction in energy consumption has been a strategic policy of the European Union, namely after 2002, in a perspective of increasing the efficiency for the use of this input. On the other hand, in the farming sector, energy efficiency may be quantified as the energy needed by unit of output [8].

The type of crop, as well the agronomic management (rotation between crops) and the management techniques in farms are fundamental to the efficiency of the energy consumed in agriculture [9]. In animal production, the feed, generally, consumes a greater part of the total energy used [10], so the management techniques related with these practices, must be adjusted and well designed. In fact, crop rotation, fertilization and animal feed, are farm management practices that may make huge differences, in terms of agricultural energy efficiency [11]. On the other hand, the characteristics of the machinery used, namely tractors, and the working conditions for this equipment, influence, also, the efficiency of the energy consumed in farms [12,13]. Kouřilova and Sedlaček [14] also stressed the dependence of energy consumption upon machine management, inputs, technologies and changes in the costs framework.

The efficiency in energy consumed by the farming sector of the several European Union countries is different [15], which suggests a need for different and adjusted energy policies, namely when we think about improvements in the way of utilizing this input in agriculture. For example, in Irish dairy farms, there is more potential to reduce the costs for electricity in the larger farms, than in the smaller or medium farms, by changing milking times [16].

The consumption of non-renewable energy in agriculture reduces energy efficiency, but it is still increasing. Organic farming seems to be an alternative to reduce the consumption of this kind of energy and to increase the efficiency in the energy consumed within the agricultural sector [17]. However, for example, the Dutch dairy farms, namely those with environmental concerns, have a lower non-renewable energy use, specifically because of the farming techniques used [18]. Non-renewable energy use continues to be related with the environmental performance in farms, namely in the Dutch pig fattening farms [19]. In France farms with cereals and cash crops are those with greater non-renewable energy use, related with more utilization of fertilizers [20].

Another question refers to the implications of the farmers' management skills and their capacity to use the available information and management techniques. Indeed, in the last few years several online platforms have appeared with much information, namely statistical information. However, Csajbok et al. [21] showed that the use of management information by agricultural operators, in Dutch farms, brings about reductions in materials and services and, subsequently, increases in energy use.

The dedicated energy crops are another question for the energy framework in European Union farms, however the acceptance on the part of the farmers, namely in England is not so enthusiastic, due to several factors, such as land quality, available machinery and profitability [22]. Renewable energy use and self-sufficient energy farms are, also, questions in the order of the day [23].

The following Table 1 presented summarizes the literature survey made in this section, showing the methodology used, the country or countries considered as a base of research and the key challenges proposed by the different authors. This table better allows us to understand the originality of the work developed here and appreciate the latest findings about these issues.

The literature survey showed that there are not many scientific studies concerning energy consumption in agriculture for the twelve former European Union countries, stressing its efficiency and the multiplier effect this has on the agricultural economic dynamic, and less, or none, at farm level and by using the methodology proposed (model, data and econometric techniques).

This study is a contribution that may fill this gap, shedding some light upon these fields that can be used by policy makers in the European Union and by operators associated with the energy and farming sectors.

Table 1 reveals that energy efficiency, sustainable production and the environmental impact, are the main focus of the analyzed studies in the literature survey. On the other hand, a significant part of these studies used the typical data envelopment analysis, process analysis methodology and life cycle assessment, as base methodologies. In general, there are individual countries, as the spatial base for the research. Finally, the questions related with the relationships between productivity, energy consumption, energy efficiency, the farms productivity and the energy costs were explicitly or implicitly suggested by several authors, as being key challenges for the future.

These economic analyses in the fields of agriculture and energy, which were referred by various authors, as topics for future