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Energy Use And Intensity in Agriculture Across European Countries

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ABSTRACT

This paper employs index decomposition analysis to decompose the energy consumption in agricultural sectors across the selected European Union Member States. The data from the World Input-Output Database are used for the analysis. The research covers the period of 1995–2009. The analysis showed that most of the selected European Union Member States managed to decouple the growth in agricultural Gross value Added and energy consumption during 1995–2009. The variance in energy intensities across the countries analysed did not fall until 2002, yet a moderate decrease has been observed afterwards. The results of the index decomposition analysis suggests that such countries a Austria, Finland, France, and Slovenia could exploit the intensity effect in reducing the overall energy use to a higher extent.

1. INTRODUCTION

The use of energy resources renders both economic and environmental consequences. From the economic viewpoint, energy is one of the factor inputs and, subsequently, the use of energy is associated with respective production cost. Therefore, the energy efficiency is an important driver of competitiveness. The environmental approach stresses the energy flows and their impact upon environment. Indeed, energy-mix alongside the level of combustion technologies determines the level of greenhouse gas emissions (Robaina-Alves, Moutinho, 2014; Makarenko, Streimikiene, 2014).

The European Union (EU) has acknowledged the importance of energy efficiency and set so-called 20/20/20 targets for year 2020 (European Commission, 2010). Specifically, these targets define an increase in the share of renewables, an increase in energy efficiency, and a decrease in greenhouse gas emission. The recent data show that the aforementioned goals are likely to be met or have already been met (Eurostat, 2015). However, Roadmap of 2011 (European Commission, 2011) and the 2030 framework for climate and energy policies (Council of the European Union, 2014) put new objectives for emission reduction. In the light of these requirements, it is important to analyse the use of energy and its drivers in the EU (Ruester et al., 2014; Balcerzak, 2015; Terem et al., 2015).

The analysis of energy consumption requires to provide insights not only in regards to the quantities used or saved, but also to identify the underlying factors of such changes. The key techniques employed for the latter purpose are index decomposition analysis (IDA) and structural decomposition analysis (Hoekstra, van den Bergh, 2003; Kasperowicz, 2014). One of the most popular IDA techniques is the Logarithmic Mean Divisia Index (Ang et al., 1998; Ang, 2005, 2015). IDA has been applied in a number of energy-related studies: Baležentis et al. (2011) applied IDA to analyse the changes in energy consumption in Lithuanian economy. Baležentis and Baležentis (2011) employed the same technique to analyse energy consumption and carbon emission in Lithuanian agricultural sector. Robaina-Alves and Moutinho (2014) decomposed the changes in carbon emission in agricultural sectors of the selected EU countries. However, none of these studies compared Lithuanian agricultural sector against the remaining ones in terms of decomposition of changes in energy use.

This paper employs IDA to decompose the energy consumption in agricultural sectors across the selected EU Member States. The following tasks are set: 1) to describe the IDA framework; 2) to present the data used; 3) to analyse the main trends in absolute and relative indicators of energy use in agriculture; 4) to decompose the changes in energy use into the effects of energy intensity and economic activity. The data from the World Input-Output Database (WIOD) are used for the analysis (Timmer et al., 2012). The research covers the period of 1995–2009.

2. DATA AND METHODS

Given we focus on a single economic sector, the Logarithmic Mean Divisia Index collapses to a simple ratio analysis. Energy consumption is related to economic activity by using a multiplicative relation involving overall industrial activity (activity effect) and energy intensity (intensity effect). Therefore, the following IDA identity describes the total energy consumption:

$$E = Q\frac{E}{Q} = QI \,, \tag{1}$$

where *E* denotes the total energy consumption in the agricultural sector, Q is the economic activity level (as represented by Gross Value Added), and I is the energy intensity. As this research aims at international comparison, the relative measures are preferable. Therefore, the multiplicative decomposition is facilitated as follows:

$$D = E^T / E^0 = D_{act} \cdot D_{\text{int}} \,. \tag{2}$$

In Eq. 2, E^T and E^0 are energy consumption volumes during period *T* and 0, respectively; the subscripts *act* and *int* denote the impacts of activity effectand intensity effect, respectively. Consequently, these effects are calculated by employing the following equations for multiplicative decomposition:

$$D_{act} = \frac{Q^T}{Q^0}, \tag{3}$$

$$D_{str} = \frac{I^T}{I^0}. \tag{4}$$

In order to ease the presentation, we further log both sides of Eq. 2:

$$\ln D = \ln D_{act} + \ln D_{\text{int}} \,. \tag{5}$$

The data from the WIOD (Timmer et al., 2012) are applied for the research. The data cover years 1995–2009. Specifically, the research considers the time series for sector Agriculture, Hunting, Forestry and Fishing (NACE 1.1 sectors A-B). In order to facilitate the international comparisons, the Gross Value Added (GVA) is deflated by the means of respective price indices from the WIOD (base year 1995) thus constructing the implicit quantity indices. Furthermore, purchasing power parities of 1995 based on the EU-28 Gross Domestic Product are used. Therefore, the monetary terms used in this study are expressed in purchasing power standards (PPS) of 1995. Such manipulations allow one to account for price and exchange rate differences, existing among the analysed states.

3. RESULTS

The general trend, prevailing in agriculture of the analysed EU Member States, was a growth in agricultural GVA coupled with a decrease in energy consumption (Table 1). Indeed, the growth in the real GVA ranged in between (-21%) for Romania and 103% for Slovakia during 1995–2009. The sample mean, thus, was 23%. Out of the analysed countries, only few experienced a decrease in agricultural GVA, viz., Slovenia (-1%), Austria and Czech Republic (-7%), and Romania (-21%) during 1995–2009. Obviously, the larger agricultural producers with mean agricultural GVA exceeding 15 billion PPS, i.e., Germany, France, Romania, and Poland, showed lower (or even negative) growth rates if opposed to the other countries.

Table 1. Variation of energy consumption and CO_2 emission related indicators across the selected EU Member States, 1995–2009

Member States	Gross value added, million PPS				Energy consumption, TJ			
	Rate of growth, %	Mean	Standard deviation	CV	Rate of growth, %	Mean	Standard deviation	CV
Austria	-7	3463	179.1	0.05	0	25766	1942.2	0.08
Belgium	2	2723	121.7	0.04	-25	38325	7207.5	0.19
Bulgaria	3	6675	835.1	0.13	-36	18813	3057.5	0.16
Czech Republic	-7	4893	463.4	0.09	-54	30288	7302.6	0.24
Germany	14	19648	1499.5	0.08	-36	169601	38541.8	0.23
Denmark	29	3240	259.2	0.08	-4	50286	1916.0	0.04
Estonia	60	553	80.6	0.15	5	4381	709.9	0.16
Finland	18	3167	277.4	0.09	12	37941	2465.4	0.06
France	16	32889	1689.6	0.05	-3	190700	5094.0	0.03
Hungary	67	6675	1531.8	0.23	-31	30398	3847.1	0.13
Lithuania	27	2102	169.9	0.08	-36	8239	1338.6	0.16
Latvia	35	710	94.7	0.13	-26	7756	857.5	0.11
Netherlands	23	9379	623.9	0.07	-36	241818	48555.8	0.20
Poland	21	18445	1154.8	0.06	-26	215392	28400.5	0.13
Romania	-21	17377	1758.0	0.10	-40	34955	10358.8	0.30
Slovakia	103	2646	717.9	0.27	-53	9686	2860.6	0.30
Slovenia	-1	857	46.4	0.05	0	5043	1321.7	0.26
Sweden	34	4706	579.5	0.12	-13	35450	2750.1	0.08

Data source: World Input-Output database

The trends in energy consumption are somewhat less certain across the larger and other agricultural producers. Specifically, the four largest producers, as mentioned above, experienced a decrease in energy use. France saw a decrease of only 3% during 1995–2009, whereas the corresponding figures for the remaining three large producers ranged in the interval of (-36%) and (-26%). As regards the whole sample, the range for rate of growth in energy consumption was bounded by the values of (-54%) for Czech Republic and 12% for Finland. All in all, only Estonia and Finland featured positive rates of growth in energy consumption. However, a substantial growth in the agricultural GVA of some 60% was observed for Estonia. Meanwhile, the corresponding figure for Finland was only 18% suggesting a lack of energy efficiency measures in Finnish agriculture. Austria and Slovenia showed nil changes, albeit a slight growth was observed for the latter country.

Considering the “smaller” agricultural producers, the steepest plunge in energy consumption was observed for Czech Republic and Slovakia. Indeed, energy consumption went down by 53% in the latter country. Another group of “smaller” producers comprises Lithuania, Bulgaria, the Netherlands, Hungary, Latvia, and Belgium. The latter group showed a decrease of more than 20%, yet did not reach the one experienced by Czech Republic and Slovakia. Finally, energy consumption in Sweden and Denmark plunged by 13% and 4%, respectively.

The changes in the two absolute variables, viz. agricultural GVA and energy consumption, are linked by a relative indicator, namely energy intensity. Indeed, a decrease in energy intensity indicates the decoupling of energy use and economic activity. In the presence of the climate change processes, such a decrease is sought after in the EU. We, therefore, further look at the dynamics of the latter indicator in selected EU Member States. Table 2 below presents the results.

Table 2. Dynamics and variation of energy intensity (kJ per PPS) across the selected EU Member States, 1995–2009

Member States	1995	2009	Rate of growth, %	Mean	Standard deviation	CV
Austria	6.3	6.8	7	7.5	0.7	0.1
Belgium	18.5	13.6	-26	14.2	3.1	0.2
Bulgaria	3.9	2.4	-38	2.9	0.7	0.3
Czech Republic	10.9	5.4	-50	6.2	1.5	0.2
Germany	12.9	7.2	-44	8.8	2.5	0.3
Denmark	16.4	12.2	-25	15.6	1.3	0.1
Estonia	10.5	6.9	-34	8.1	1.7	0.2
Finland	11.1	10.6	-5	12.0	1.1	0.1
France	6.2	5.1	-17	5.8	0.3	0.1
Hungary	6.3	2.6	-58	4.8	1.4	0.3
Lithuania	5.7	2.9	-50	3.9	0.8	0.2
Latvia	14.7	8.1	-45	11.1	2.2	0.2
Netherlands	32.5	17.0	-48	26.1	6.7	0.3
Poland	14.0	8.5	-39	11.8	2.1	0.2
Romania	2.7	2.0	-24	2.0	0.5	0.3
Slovakia	7.3	1.7	-77	4.1	2.0	0.5
Slovenia	5.3	5.4	1	5.9	1.5	0.3
Sweden	8.7	5.6	-35	7.7	1.3	0.2

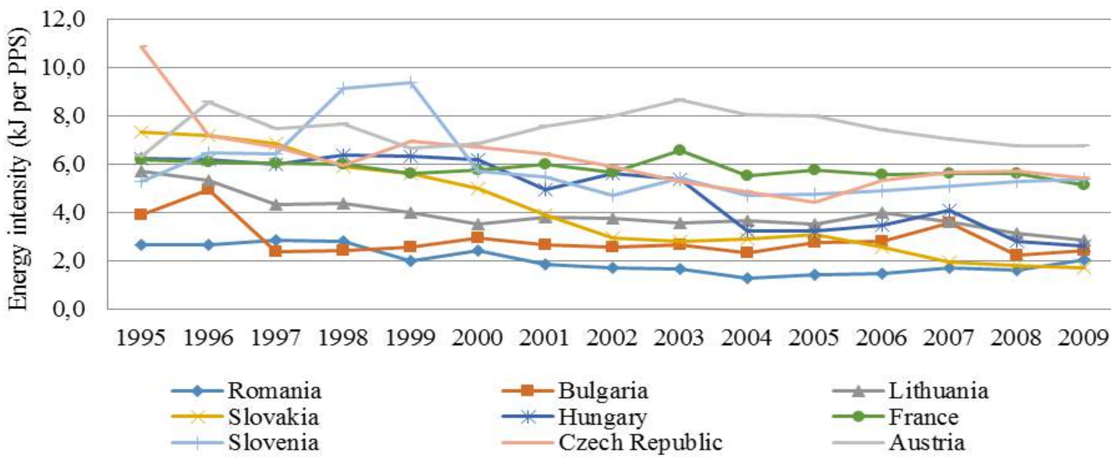
Data source: World Input-Output database

The highest energy intensity, as of 1995, was observed in the Netherlands (32 kJ per PPS). The other countries showed significantly lower intensities. Specifically, Belgium and Denmark stood at intensities of 18.5 and 16.4 kJ per PPS, respectively. Latvia, Poland, and Germany all were specific with the values of 14.7-12.9 kJ per PPS in 1995. Obviously, countries associated with the highest energy intensities specialise in vegetable and livestock farming, which require indoor facilities. However, situation in Latvia might have been related to unfavourable climatic conditions which induce relatively low agricultural output per energy unit consumed.

A positive change was observed for the period of 1995–2009 as energy intensity dropped in most of the analysed countries. The steepest decrease was observed in Slovakia, where energy intensity dipped from 7.3 down to 1.7 kJ per PPS, i.e., a decrease of 77% was observed. This process was mainly fuelled by an increasing productivity of Slovakian agriculture, which resulted in a steeply increasing agricultural GVA (cf. Table 1). Accordingly, Slovakia became the least energy-intensive country in 2009. Czech Republic, Lithuania, and Hungary also experienced tremendous decreases in energy intensity of 50-58%. Czech Republic and Hungary increased their relative positions among the analysed countries, whereas the opposite was observed for Lithuania. Even though energy intensity went down by some 48% in the Netherlands, the latter country remained as the first one among the analysed countries. An increase in energy intensity was observed for Austria and Slovenia. Indeed, the increases were not decisive as that for the former country accounted for 7% and that for the latter – 1%.

In order to analyse the temporal patterns of energy efficiency change, we attempt to look at the two groups of the selected EU Member States. Specifically, Figure 1 presents the trends of energy intensity across low-intensity countries, where mean intensity was 7.5 kJ per PPS or less, whereas Figure 2 depicts the corresponding trends for countries with energy intensity exceeding the latter limit.

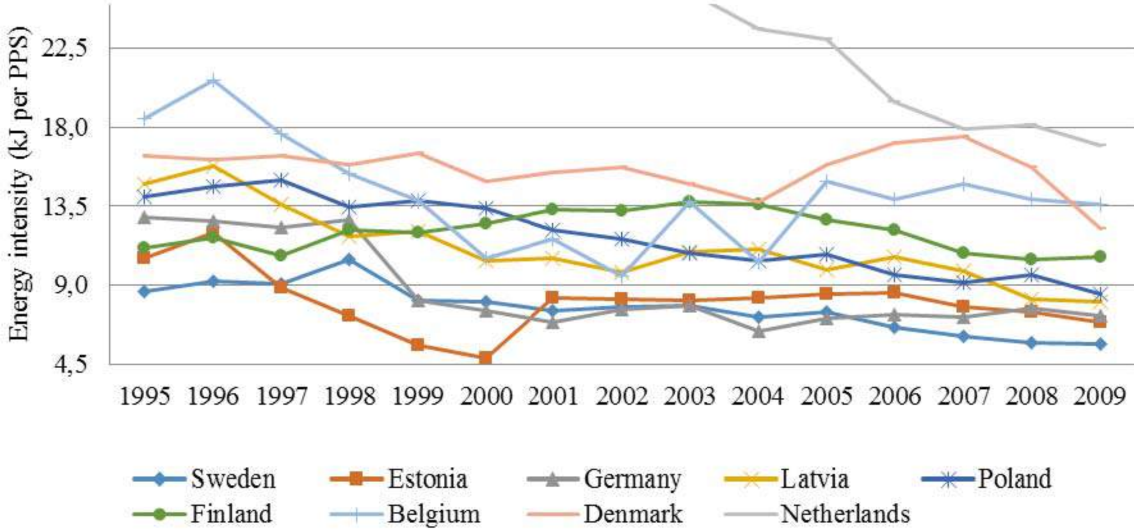
Figure 1. Energy intensity in the selected EU Member States agricultural sector, 1995–2009 (mean intensity <7.5 kJ per PPS)



Data source: World Input-Output database

As one can note, the trends depicted in Figures 1–2 show that energy intensity had generally decreased in the analysed countries during 1995–2009. However, various shocks occurred across different countries at different time periods. In general, these shocks are governed by changes in productivity and / or energy efficiency. Indeed, energy efficiency is also related to farming structure and specialisation in respective countries. Given the trajectories of energy intensity change are rather different across the EU Member States analysed, a convergence analysis is facilitated.

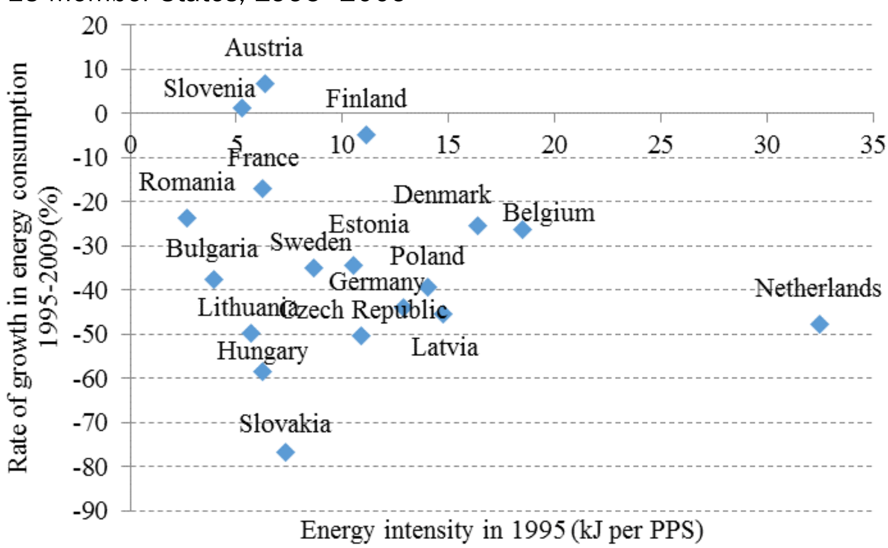
Figure 2. Energy intensity in the selected EU Member States agricultural sector, 1995–2009 (mean intensity >7.5 kJ per PPS)



Data source: World Input-Output database

There are two main types of convergence, viz., β-convergence, which indicates that the countries approach the same level of variable under analysis (e.g., energy intensity), and σ-convergence, which indicates a decreasing variance among the analysed countries. It is due to Young et al. (2008) that β-convergence is a necessary yet not sufficient condition for σ-convergence. We therefore look at the two issues in the sequel. First, Fig. 3 depicts the relationships between energy intensity in the initial period, i.e., year 1995, and the rate of growth for the period of 1995–2009 for the selected EU Member States.

Figure 3. The relationships between energy intensity in 1995 and rate of growth thereof across the selected EU Member States, 1995–2009



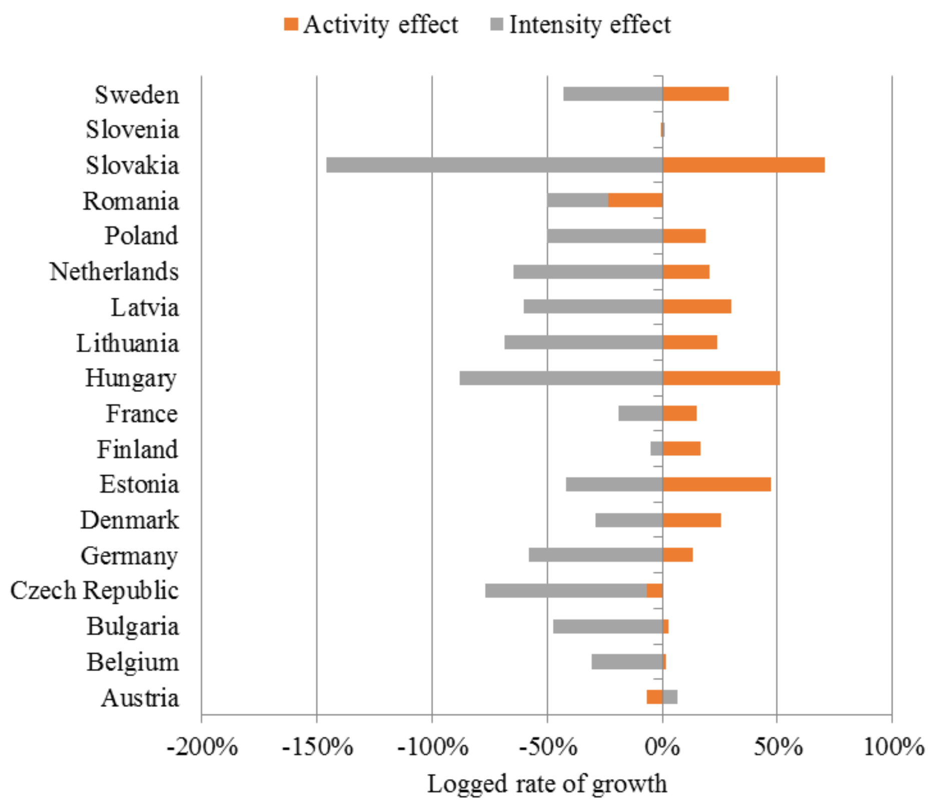
Data source: World Input-Output database

After grouping the countries considered, one can derive several conclusions. As Figure 3 suggests, there exists a β-convergence among the selected EU Member States, however it differs across certain groups of the countries. First, Romania, Bulgaria, Lithuania, Hungary, and Slovakia compose the group of countries, where the rate of growth was extremely high and its elasticity with respect to the initial intensity level was also high. Second, the group comprising Austria, Slovenia, France, Sweden, Germany, Czech Republic, Poland, and Estonia showed medium elasticity. Finally, the group of Finland, Denmark, Belgium, and the Netherlands was specific with the lowest elasticity (rate of convergence) and rather high levels of the initial energy intensity. The aforementioned grouping, indeed, basically corresponds to economic development of the countries.

Considering the σ-convergence, the coefficient of variation (CV) showed that the two stages in this type of convergence can be defined for the selected EU Member States during the period of 1995–2009. The first period covers years 1995–2002. During the latter period, the CV for energy intensity had been decreasing during 1995–1997 and rebounded thereafter peaking on 2002. The period of 2002–2009 marked a decrease in CV and, therefore, σ-convergence. This finding might be explained by more stable agricultural markets on the one hand and a more intensive implementation of energy-saving technologies on the other.

Therefore, different patterns of changes in energy intensity and economic activity were present in different regions of the EU. Hence, the multiplicative LMDI decomposition was employed to quantify the main factors of changes in energy consumption across the selected EU Member States. The results are presented in Figure 4. Note that the rates of growth related to Figure 4 are given in logged form to ensure the additive decomposition of the relative measures.

Figure 4. Decomposition of changes in energy use across the selected EU Member States, 1995–2009



Data source: World Input-Output database

The highest relative decreases in energy consumption (in logged terms) were observed in Czech Republic (-77%) and Slovakia (-75%). Even though the rates of decrease are similar, the decomposition of changes in energy consumption showed certain differences in the underlying factors: A positive activity effect was observed in Slovakia and a negative intensity effect of nearly 150% offset it. As for Czech Republic, the whole change in energy use was mainly driven by a negative intensity effect. Bulgaria, Germany, Lithuania, the Netherlands, and Romania showed important decreases in energy consumption of 44–50%. In most of these countries, intensity effect outweighed activity effect. However, this does not hold for Romania and Bulgaria, where activity effect was either negative or close to nil. Poland, Latvia, and Belgium comprise the group of countries with rates of decrease close to 30%. Poland and Latvia exploited both activity and intensity effects, with the latter one outweighing the former one, whereas the change in energy consumption in Belgium was mainly driven by intensity effect. A decrease in energy consumption of some 14% was observed in Sweden, where activity effect played a rather important role. Austria, Denmark, and France showed rather meagre rates of decrease in energy consumption. Note that the magnitude of intensity and activity effects varied across the countries. The decomposition analysis further suggested that Austria and Slovenia were the only countries where intensity effect was positive (however, the overall changes in energy consumption there were extremely small). Finally, Estonia and Finland were specific with positive rates of growth in energy consumption, viz., 5% and 12%, respectively. A relatively lower impact of intensity effect in Finland and Estonia suggests that the latter countries can still implement more energy efficiency measures in agricultural sector.

The highest absolute energy savings had been achieved in the Netherlands (102 thousand TJ), Germany (82 thousand TJ) and Poland (63 thousand TJ). The IDA showed that the intensity effect pushed the energy consumption down by some 50% there. This result indicates that increase in energy efficiency is a promising avenue for development of the EU agriculture.

4. CONCLUSIONS

The analysis showed that most of the selected European Union Member States managed to decouple the growth in agricultural Gross value Added and energy consumption during 1995–2009. Such a trend suggests that the agricultural sector has successfully followed the objectives of the European Union energy policy.

The convergence in energy intensity is rather complicated in agricultural sector. Specifically, there have been several groups of countries identified with different patterns of convergence in energy intensity therein. It turned out that Northern European countries show lower elasticity of energy intensity (with respect to the initial level of intensity) if opposed to Central and East European ones. The variance in energy intensities across the countries analysed did not fall until 2002, yet a moderate decrease has been observed afterwards.

The results of the index decomposition analysis suggests that such countries a Austria, Finland, France, and Slovenia could exploit the intensity effect in reducing the overall energy use to a higher extent. This can be achieved by increasing the energy efficiency through technology adaption or alterations in the product mix.

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