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RESOURCE USE AND PRODUCTIVITY IN AGRICULTURE ACROSS THE EUROPEAN UNION MEMBER STATES

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Abstract. This paper aims to analyse the trends in resource use across the European Union (EU) Member States. The research relies on concept of decoupling between the resource use and economic activity. Indeed, the analysis focuses on the general trends in the energy, land, and water resource as well as material consumption. The cases of decoupling across the EU Member States are presented in the paper in order to disentangle the linkages between economic activity and resource use. The research relies on the WIOD data for 1995-2009. In general, it can be concluded that energy and land were those inputs (production factors) which have been used in the most sustainable way if opposed to the remaining inputs covered in this study.

Key words: resources, decoupling, agriculture.

JEL code: Q15, Q56.

Introduction

Economic activity is mainly aimed at transforming inputs to outputs and, thus, satisfying the needs of society. Efficiency of suchlike activity can, hence, be measured by considering the ratio of output production to input use. Furthermore, the total output can be maximized by making the productive process more extensive (increase in scale) or intensive (increase in productivity). Whereas the limits for increase in the scale of production are more or less clearly defined by physical restrictions of the production system and associated production factors, the limits for increase in productivity are much vaguer. Indeed, the comparative analysis (benchmarking) can provide yardstick for possible improvements in the production systems. Therefore, it is important to develop and apply the benchmarking frameworks in order to identify the best practice and possible limits for growth.

The traditional approach is to measure the relative indicators like gross value added (GVA) per unit of labour etc. However, it is not always possible to include all sorts of costs into

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analysis as some inputs are public goods or common goods and, accordingly, require no "tangible" expenses for consumption thereof. The latter issue is especially topic for natural resources, viz. water, air etc. such inputs as land, materials etc. might also be used excessively due to market imperfections ownership rights. In addition, such undesirable outputs as carbon emission need also to be taken into account as they induce climate change along with further negative externalities. Due to the aforementioned circumstances, one needs to analyse the "physical economy", i. e. the use of resources along with economic activity. Weisz et al. (2006) analysed the trend in material consumption across the European Union Member States. Galli et al. (2012) proposed an integrated framework for analysis of the human impact. The latter framework comprises the ecological footprint, the water footprint, and the carbon footprint. The concept of eco-efficiency is further discussed by Keating et al. (2010).

At the level of the European Union, the need for analysis of resource efficiency was stressed by launching a flagship initiative "A resource-efficient Europe" (European Commission, 2011). In this vein, the associated data bases were established for international comparisons. These are, for instance, EU KLEMS (O'Mahony, Timmer, 2009) and the World Input-Output Database (WIOD) described by Timmer et al. (2012).

In a competitive environment, the productive processes are performed and influenced by multiple agents at different levels. In order to streamline the production system at sector or region, an instance of benchmarking is usually required. This is especially important in the agricultural sectors of the EU Member States which are subject to the Common Agricultural Policy.

These findings undoubtedly urge to analyse not only economic variables available by the virtue of accounting (cf. Farming Accountancy Data Network), but also physical flows of materials and input use. Indeed, the latter information is hard to measure and, due to that, only certain estimates are available. Balezentis and Hougaard (2014) performed the analysis of resource use in Lithuanian agriculture. However, in order to reveal the possible ways for improvement.

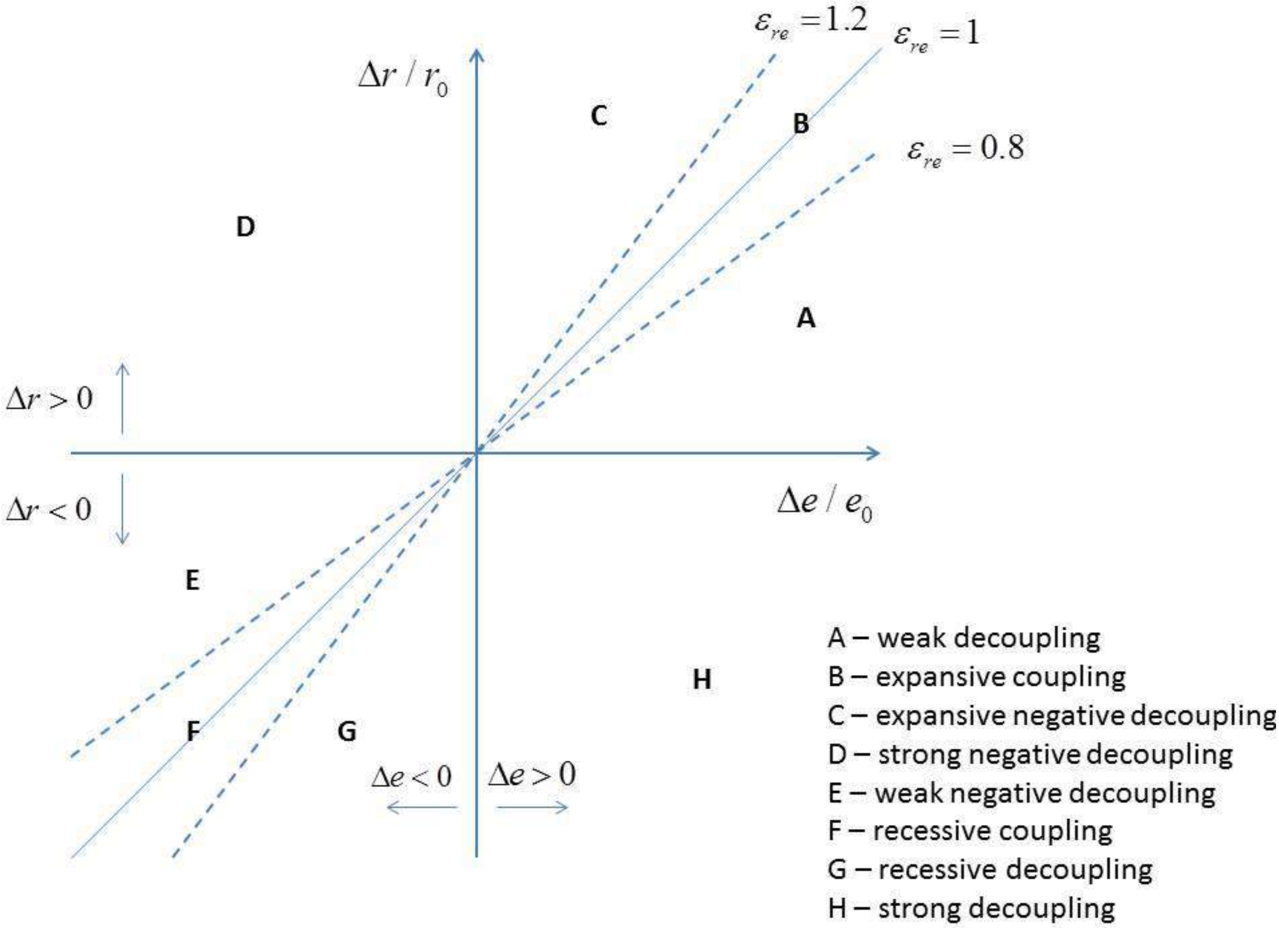
This paper aims to analyse the trends in resource use across the EU Member States. The following tasks are set: (i) to present the methodology for analysis of decoupling between the resource use and economic activity, (ii) to present the general trends in the resource use, and (iii) to analyse the cases of decoupling across the EU Member States. The research relies on the WIOD data for 1995-2009.

Methodology

The key concept for analysis of the resource use and decoupling, in particular, is resource use elasticity. It can be defined in terms of the levels of resource use and economic activity. Say r_0 and r_t are the quantities of resources used in the base and current period, respectively. Similarly, assume e_0 and e_t denote the quantities of output, i. e. results of the economic activity in the base and current period, respectively. Thenceforth, the elasticity of resource use, ε_{re}, is defined as (Tapio, 2005):

$$\varepsilon_{re} = \frac{\Delta r / r_0}{\Delta e / e_0} = \frac{(r_t - r_0) / r_0}{(e_t - e_0) / e_0}. \tag{1}$$

However, the measure of elasticity cannot fully describe the underlying trends in resource use. This can be done by considering it alongside changes in resource use and economic activity. The four axes and the two dashed lines in Figure 1 delineate the eight types of (de)coupling.



Source: authors' construction based on Tapio (2005) and Song, Liu (2014).

Fig. 1. **A graphical interpretation of the (de)coupling concept**

Weak decoupling can alternatively be termed relative decoupling, i. e. the rate of increase in economic activity induces is higher than that in resource use. At the other end of spectrum, strong decoupling can be termed absolute decoupling, i. e. the changes in economic activity and resource use occur towards different directions. Negative decoupling occurs whenever resource use is disproportional to changes in economic activity. Finally, expansive (resp. recessive) decoupling is related to economic growth (resp. downturn).

The research relies on the data from the WIOD (Timmer, 2012). The data cover years 1995–2009. Specifically, the research focuses on the data series for the Agriculture, Hunting, Forestry and Fishing sector (NACE 1.1 sectors A-B). In order to facilitate the international comparisons, the gross value added is deflated by respective price indices available in 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, which are devoid of price and exchange rate differences, otherwise existing among the analysed states. Note that the WIOD presents material extraction rather than direct material consumption.

Results

First of all, the general trends for the agricultural gross value added (GVA) are presented to describe the relative importance of agriculture in the economic sense. The obtained results (Table 1) are based on the WIOD data base (Timmer, 2012).

Table 1

Dynamics of the agricultural value-added across the selected EU Member States, 1995-2009

Member States	The share of agricultural sector in the total GVA, per cent				Rate of growth, per cent
	1995	2009	Average	CV	
Austria	2.6	1.9	2.1	0.13	-6.7
Belgium	1.5	1.2	1.4	0.10	1.7
Bulgaria	15.7	12.5	17.5	0.23	2.8
Czech Rep.	5.0	3.2	4.2	0.15	-6.7
Germany	1.3	1.2	1.3	0.08	14.4
Denmark	3.5	3.7	3.2	0.10	29.1
Estonia	5.8	4.9	5.3	0.19	60.0
Finland	4.5	3.6	3.5	0.13	18.1
France	3.3	3.0	3.1	0.08	16.5
Hungary	8.0	9.5	7.9	0.14	66.6
Lithuania	11.0	7.4	8.6	0.22	27.1
Latvia	9.1	6.4	6.7	0.17	35.1
Netherlands	3.5	3.1	3.1	0.07	22.9
Poland	8.0	5.4	6.5	0.13	21.1
Romania	19.2	10.6	15.4	0.20	-20.7
Slovakia	5.9	6.5	5.7	0.09	102.9
Slovenia	4.4	2.7	3.6	0.19	-0.7
Sweden	3.0	2.9	2.7	0.06	33.5

Source: authors' calculations based on Timmer (2012).

These results are rather important in the sense that the general trends in GVA enable to describe the overall development of the agricultural sectors across the selected EU Member States, the corresponding decoupling types, and provide an overview on the data available in the WIOD. Table 1 presents the main results regarding GVA generated in the agricultural sector, viz., the share of the agricultural sector in the total GVA generated in an economy for 1995 and 2009, an average value, coefficient of variation (CV), and the rate of growth in the volume of the GVA in agriculture. Therefore, one can analyse the trends in both the relative importance of the agricultural sector and the absolute change in its output across the EU Member States.

In order to define the prevailing types of decoupling, the partial productivities of the resources used in the agricultural sector are analysed. Specifically, Table 2 presents the results related to energy use, whereas Table 3 deals with land, material use, and water productivity.

Table 2

Partial productivity of energy use and carbon emission, 1995-2009

Member States	**Energy use productivity (million PPS / TJ)**			**Carbon emission productivity (million PPS / kt)**		
	Average	**Rate of growth**	**CV**	**Average**	**Rate of growth**	**CV**
Austria	0.14	-6	0.10	3.37	15	0.10
Belgium	0.07	36	0.22	0.97	28	0.09
Bulgaria	0.36	60	0.19	6.62	-11	0.17
Czech Rep.	0.17	101	0.19	1.78	21	0.18
Germany	0.12	78	0.23	2.33	84	0.22
Denmark	0.06	34	0.09	1.29	53	0.11
Estonia	0.13	52	0.23	3.35	2	0.44
Finland	0.08	5	0.09	1.52	42	0.15
France	0.17	21	0.06	2.35	26	0.07
Hungary	0.23	141	0.35	4.71	173	0.38
Lithuania	0.26	99	0.17	6.32	104	0.21
Latvia	0.09	83	0.18	1.54	63	0.14
Netherlands	0.04	91	0.26	0.92	31	0.11
Poland	0.09	65	0.19	1.24	60	0.17
Romania	0.53	31	0.26	36.27	242	0.47
Slovakia	0.31	330	0.49	27.39	25	0.31
Slovenia	0.18	-1	0.19	3.69	17	0.06
Sweden	0.13	54	0.18	1.93	10	0.09

Source: authors' calculations based on Timmer (2012).

Energy productivity clearly depended on the geographical location of the analysed countries: the Southern countries featured higher levels of energy productivity if opposed to the Northern ones. Lithuania might be an interesting exception with rather low energy intensity. The correlation between average energy productivity and rate of growth in productivity (R = 0.14) indicates that the divergence in energy productivity/intensity is not likely to deepen in the analysed countries. As regards carbon emission productivity, the pattern of country ranking remained more or less the same. However, a positive correlation coefficient between average carbon emission productivity and CV (R = 0.48) implied that high-productivity countries face higher variance in carbon emission productivity. Note that energy productivity decreased in Austria (-6%) and Slovenia (-1%) during the research period. Carbon emission productivity decreased in Bulgaria only.

Table 3

Partial productivity of land, water, and materials, 1995-2009

Member States	Land productivity (thousand PPS / ha)			Material use productivity (thousand PPS / t)			Water productivity (PPS / m3)		
	Average	Rate of growth	CV	Average	Rate of growth	CV	Average	Rate of growth	CV
Austria	0.54	-9	0.08	0.08	-13	0.08	0.57	-9	0.06
Belgium	1.35	5	0.05	0.07	15	0.06	0.81	-3	0.05
Bulgaria	0.84	13	0.14	0.31	-13	0.17	0.40	6	0.16
Czech Rep.	0.79	-12	0.09	0.13	-2	0.12	0.37	-17	0.13
Germany	0.79	22	0.10	0.07	20	0.10	0.38	-7	0.05
Denmark	1.10	30	0.09	0.09	35	0.08	0.34	14	0.06
Estonia	0.19	19	0.10	0.08	31	0.11	0.17	-8	0.23
Finland	0.14	7	0.08	0.07	8	0.07	0.54	0	0.08
France	0.74	17	0.05	0.11	4	0.03	0.41	-3	0.03
Hungary	0.93	79	0.25	0.15	41	0.12	0.25	49	0.14
Lithuania	0.46	50	0.13	0.12	11	0.11	0.22	-32	0.11
Latvia	0.19	8	0.14	0.03	-8	0.19	0.17	-31	0.13
Netherlands	4.27	22	0.07	0.22	-8	0.04	1.76	24	0.09
Poland	0.82	25	0.09	0.10	0	0.06	0.36	18	0.10
Romania	0.99	-15	0.10	0.23	-2	0.07	0.45	-8	0.14
Slovakia	0.86	93	0.27	0.13	44	0.20	0.43	104	0.26
Slovenia	0.66	-13	0.10	0.14	-1	0.05	0.55	-1	0.06
Sweden	0.24	30	0.12	0.07	31	0.12	0.53	23	0.17

Source: authors' calculations based on Timmer (2012).

Table 3 presents the partial productivity of land, material use, and water. Note that Romania and Bulgaria exhibited rather high land productivity levels of 0.99 and 0.84 thousand PPS/ha, respectively. This might be due to the fact that the WIOD database includes forestry GVA and productive forest area into account. It is important to take into account that the use of implicit quantity indices involved in the analysis has also altered the real output levels. The same observations can be made for material use productivity. Anyway, these countries showed negative growth rates for the aforementioned variables (save for land productivity in Bulgaria), thus, analysis of the extended time series might reveal some additional insights. The three Baltic States performed the worst in terms of the average water use productivity. Indeed, the abundance of the latter resource there induces excessive use thereof.

Given the results presented in Table 1 and the rates of growth of resource consumption (these data are available from the corresponding author upon request), the prevailing types of (de)coupling were identified for the analysed countries. Table 4 presents the results, namely elasticities of resource use and the associated types of (de)coupling. The types of decoupling are denoted in the same manner is in Figure 1.

Table 4

Elasticities of resource use and the types of (de)coupling, 1995-2009

Member States	Energy use		Carbon emission		Land		Material consumption		Water	
	Elasticity	Type	Elasticity	Type	Elasticity	Type	Elasticity	Type	Elasticity	Type
Austria	0.0	A	2.8	G	-0.4	D	-1.1	D	-0.4	D
Belgium	-15.2	H	-12.3	H	-1.9	H	-6.9	H	2.8	C
Bulgaria	-12.8	H	5.5	C	-3.2	H	6.4	C	-0.9	H
Czech Republic	8.0	G	3.4	G	-0.8	D	0.7	E	-1.9	D
Germany	-2.5	H	-2.6	H	-0.5	H	-0.3	H	1.6	C
Denmark	-0.1	H	-0.5	H	-0.01	H/A	-0.1	H	0.4	A
Estonia	0.1	A	0.9	B	0.6	A	0.4	A	1.2	C
Finland	0.7	A	-0.9	H	0.6	A	0.5	A	1.0	B
France	-0.2	H	-0.5	H	-0.03	H/A	0.7	A	1.3	C
Hungary	-0.5	H	-0.6	H	-0.1	H	0.3	A	0.2	A
Lithuania	-1.3	H	-1.4	H	-0.6	H	0.5	A	3.2	C
Latvia	-0.7	H	-0.5	H	0.7	A	1.3	C	2.7	C
Netherlands	-1.6	H	-0.3	H	0.0	A	1.4	C	0.0	H
Poland	-1.3	H	-1.1	H	-0.2	H	1.0	B	0.1	A
Romania	1.9	G	3.7	G	0.3	E	0.9	F	0.7	E
Slovakia	-0.5	H	0.6	A	0.1	A	0.4	A	-0.005	H/A
Slovenia	-0.7	D	23.0	G	-20.7	D	-1.3	D	0.003	H/A
Sweden	-0.4	H	0.6	A	0.1	A	0.1	A	0.3	A

Source: authors' calculations based on Timmer (2012).

The results did indicate that the best situation in terms of decoupling prevailed for the energy use. Indeed, some 12 of the 18 analysed countries featured strong (absolute) decoupling (denoted as H). This implies that the economic growth did not render growth in energy use but was rather maintained along with decreasing energy use. The similar trend was observed for carbon emission. However, in this case, only 10 countries were specific with absolute decoupling. This might be due to the lack of technical innovations and sustainable energy use, which induce higher values of the carbon factor. As regards the land use, 6 countries exhibited strong decoupling (type H) and another 6 – weak (relative) decoupling (type A). Even though seven countries were specific with weak decoupling for material use, there were six cases of negative decoupling (i. e. resource use grew faster than economic activity). Finally, nine instances of negative decoupling (types C, D, and E) were observed for water use.

In general, it can be concluded that energy and land were those inputs (production factors) which have been used in the most sustainable way if opposed to the remaining inputs covered in this study. Indeed, costs associated with energy and land are those easiest to internalise through the respective factor markets, whereas such inputs as materials and water are more or less freely available upon acquisition of land.

Note that the elasticities of land use in Denmark and France along with water consumption in Slovakia and Slovenia were close to zero. Therefore, the type of decoupling is rather arbitrary for these cases.

Conclusions

1. The highest relative importance of the agricultural sector (in terms of the average share of GVA in the total GVA) was observed in Bulgaria, Romania, Lithuania, Hungary, Latvia, and Poland. The average share of the agricultural GVA exceeded 6% in these economies. Negative growth rates in the agricultural GVA were observed for Slovenia (-0.7%), Austria (-6.7%), Czech Republic (-6.7%), and Romania (-20.7%).
2. In general, it can be concluded that energy and land were those inputs (production factors) which have been used in the most sustainable way if opposed to the remaining inputs covered in this study. Indeed, costs associated with energy and land are those easiest to internalise through the respective factor markets, whereas such inputs as materials and water are more or less freely available upon acquisition of land.
3. Results for the transformation economies with a history of monetary reforms might be misleading in the sense that the estimates of real value added and, thus, elasticities of resource use might had been spuriously altered during certain periods. Therefore, further analyses should attempt to (i) use different time series, (ii) employ mathematical modelling techniques able to tackle the uncertainty.

Bibliography

1. Balezentis, T., Hougaard, J. L. (2014). Resource Use in Lithuanian Agricultural Sector. *Management Theory and Studies for Rural Business and Infrastructure Development*, Volume 36, Issue 4, pp. 755-765.
2. European Commission. (2011). A Resource-Efficient Europe – Flagship Initiative under the Europe 2020 Strategy. Brussels, 26.1.2011. COM(2011) 21. Retrieved: http://ec.europa.eu/resource-efficient-europe/pdf/resource_efficient_europe_en.pdf. Access: 15.12.2014
3. Galli, A., Wiedmann, T., Ercin, E., Knoblauch, D., Ewing, B., Giljum, S. (2012). Integrating Ecological, Carbon and Water Footprint into a "Footprint Family" of Indicators: Definition and Role in Tracking Human Pressure on the Planet. *Ecological Indicators*, Volume 16, pp. 100-112.
4. Keating, B. A., Carberry, P. S., Bindraban, P. S., Asseng, S., Meinke, H., Dixon, J. (2010). Eco-Efficient Agriculture: Concepts, Challenges, and Opportunities. *Crop Science*, Volume 50, Issue S1, pp. S-109-S-119.
5. O'Mahony, M., Timmer, M. P. (2009). Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database. *The Economic Journal*, Volume 119, Issue 538, pp. F374-F403.
6. Song, W., Liu, M. (2014). Assessment of Decoupling Between Rural Settlement Area and Rural Population in China. *Land Use Policy*, Volume 39, pp. 331-341.
7. Tapio, P. (2005). Towards a Theory of Decoupling: Degrees of Decoupling in the EU and the Case of Road Traffic in Finland between 1970 and 2001. *Transport Policy*, Volume 12, pp. 137–151.
8. Timmer, M. P., ed. (2012). The World Input-Output Database (WIOD): Contents, Sources and Methods. WIOD Working Paper Number 10. Retrieved: http://www.wiod.org/publications/papers/wiod10.pdf. Access: 15.12.2014
9. Timmer, M., Erumban, A. A., Gouma, R., Los, B., Temurshoev, U., de Vries, G. J., Arto, I. (2012). The World Input-Output Database (WIOD): Contents, Sources and Methods. Retrieved: http://www.wiod.org. Access: 15.12.2014
10. Weisz, H., Krausmann, F., Amann, C., Eisenmenger, N., Erb, K. H., Hubacek, K., Fischer-Kowalski, M. (2006). The Physical Economy of the European Union: Cross-Country Comparison and Determinants of Material Consumption. *Ecological Economics*, Volume 58, pp. 676-698.