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THE POTENTİAL OF THE EUROPEAN UNİON COUNTRİES TO PRODUCE BİOMASS FOR BİODİESEL PRODUCTİON AND CONSUMPTİON PURPOSES

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This article aims at evaluating the capacity of agriculture in the member states of the European Union regarding the production of biodiesel from biomass as well as identification and empirical verification of relationships between the rapeseed market and the consumption of biodiesel. The studies were based on panel data for the EU-28 member states in the period 2010-2013 obtained from Eurostat.
The results of the studies point to significant differentiation in the production and consumption of biodiesel and its share in the consumption of liquid fuels in the transport sector in the EU. In 2010-2013 the consumption of biodiesel in EU countries exceeded 10.5 M TOE, with 2012 being a unique year when the consumption of biodiesel increased to nearly 12 M TOE. France and Germany are the leaders in the consumption of biodiesel in the EU; their consumption accounts for about 40% of the EU's consumption. In the same period in the EU countries rape was cultivated over 6673.7 k ha, with the largest area recorded also in France (1516.4 k ha) and in Germany (1390.4 k ha) - the total area of rapeseed crops in those countries accounted for 43% of the total area in the EU. In this period the annual yield of rapeseed in the 28 member states of the EU on average amounted to 19979.4 k t, 50.3% of which were crops from France and Germany.
This article proposes the construction of a theoretical model describing the relationship between the consumption of biodiesel and the key determinants of its production. The studies carried out show that the variable having the strongest impact on the consumption of biodiesel in the countries of the EU is the price of rapeseed (smaller-the-better characteristic). At the same time it was demonstrated that the consumption of biodiesel is stimulated by the supply of rapeseed.

Keywords: biodiesel, biofuels, EU Member States, rapeseed, sustainable development

INTRODUCTİON

The Rio+20 Conference which took place in 2012, start a process to elaborate a set of Sustainable Development Goals (SDGs). Many of them are reliant on biomass production that is implicit in a number of goals on food security, energy, and the protection of ecosystems (Muller et al, 2015). Biomass energy is rapidly expanding sector of commercial energy with the emphasis on developing biomass-derived fuels for transport. In the context of the principles of sustainable development an expansion of biofuels has the potential to make a positive contribution to the climate change and rural areas development (Sagar, 2007).

In 2008 the European Parliament adopted a package of acts referred to as the climate package (the so-called "3x20" Programme). The goal of the package was to initiate the "green revolution" in industry and in the energy sector of the EU by using coal reserves in order to increase the utilization of renewable energy sources. Recently interest in the use of renewable fuels has increased globally (Ajanovic, 2011). Due to increased consumption and simple utilization of diesel fuels the EU chose biodiesel as a priority biofuel in its endeavours to meet the targets set out in its Directive 2003/30/EC to promote the use of biofuels in transport. The dominant role in the production of renewable energy in the future is attributed to biomass, particularly agricultural biomass. In case of biodiesel the main addition used as a biocomponent of diesel is produced from rapeseed oil (Krička et al, 2015). In the EU, 77% of biodiesel production is produced from this oil. By Bureau et al (2010) rapeseed is the main oil crop grown in Europe accounting for more than half of the biofuel production. It is cultivated in almost all European countries (Thamsiriroj & Murphy, 2010; OECD, 2004).

According to the literature among factors affecting the consumption of biodiesel the most often are gross inland consumption of biodiesel, rape and turnip rape harvested production, rape prices and technology (Zentková & Cvengrošová, 2013; Jang & Du, 2013; Rathmann et al, 2010; Ragettli, 2007).

According to the knowledge of the authors, the capability to produce biodiesel from biomass of agricultural origin, and in particular from rapeseed, in the countries of the European Union was seldom investigated. The previous studies regarding the production of renewable energy from biomass most often focused on technical issues (i.e. Rogner, 2000; Berndes et al, 2003), taking the economic capacity into account to a lesser extent.

This article aims at evaluating the capacity of agriculture in the member states of the European Union to produce biomass for biodiesel production purposes. In determining the capacity of agriculture oriented at the production of biocomponents the point of focus was the production of rapeseed - the main crop feedstock used in the production of biodiesel in the member countries. The paper also provides identification and empirical verification of relationships between the rapeseed market and the consumption of biodiesel in the EU.

MATERİAL AND METHODS

The study uses a dataset from Eurostat over 4 years (i.e. 2010-2013) covering data on biodiesel production and consumption, rape production and prices for a sample of 28 EU countries (Table 1).

So as to find the answer for the research questions, we have applied the biodiesel consumption function in the following formula (1):

$$Biodiesel\_cons_{it} = \beta_1 Rape\_prod_{it} + \beta_2 Rape\_price_{it} + v_{it} \quad (1)$$

$i = 1, \ldots 28$, $t = 1,2,3,4$

where: β is a vector of parameters, and v_{it} is an error term specific to country i in period t.

Table 2 contains the markings and characteristics of variables used in the model.

Table 1. Gross inland biodiesel consumption (k t of oil equivalent - TOE), rape and turnip rape harvested production (k t), rape prices (EUR d kg^{-1}) in the EU Member States in 2010-2013 (average for 2010-2013)

EU Member States	Consumption	Harvested production	Rape price
Belgium	305.8	50.5	37.1
Bulgaria	58.7	418.1	37.7
Czech Republic	214.1	1160.2	41.4
Denmark	132.1	565.1	39.8
Germany	2167.9	5043.1	40.2
Estonia	0.0	151.8	41.7
Ireland	43.0	12.3	-
Greece	125.4	11.6	-
Spain	1342.7	66.5	29.8
France	2153.2	5009.4	35.1
Croatia	18.0	38.5	37.4
Italy	1256.8	39.7	32.3
Cyprus	15.8	0.0	-
Latvia	17.0	262.4	38.2
Lithuania	43.4	521.1	38.6
Luxembourg	45.6	15.5	37.3
Hungary	106.3	501.1	39.7
Malta	2.2	0.0	-
Netherlands	182.7	8.8	36.3
Austria	460.7	174.0	38.8
Poland	681.4	2158.5	39.8
Portugal	292.5	0.0	-
Romania	130.4	619.9	36.1
Slovenia	43.7	15.3	37.6
Slovakia	76.6	310.3	40.8
Finland	135.3	111.6	40.4
Sweden	301.2	295.9	40.8
United Kingdom	655.8	2418.3	38.9

Notes: " – "- no data available

Source: own elaboration based on data from Eurostat pertaining to 2010-2013 (http://ec.europa.eu/eurostat/data/database - accessed on 10/07/2015).

To estimate the biodiesel consumption equation, panel-data models are employed (Baltagi, 2005). Since our panel is relatively small and restricted to the set of 28 EU countries, there is a presumption in favor of fixed effects model. The fixed effects model decomposes v_{it} into a unit-specific and time-invariant component, α_i, and an observation specific error, ε_{it}. The individual-specific constant term absorbs the variables which are taken to be constant over time t, such as a country's specific characteristics, e.g. location, weather conditions and so on. Besides an arbitrary choice of fixed effects

model, we consider the F-test, which makes the null hypothesis that the cross-sectional units all have a common intercept. If this hypothesis is not rejected, one concludes that the simple pooled model is adequate.

Table 2. Description of the variables (with variable names).

Variable	Description
Biodiesel_cons	Gross inland biodiesel consumption (k t of oil equivalent - TOE)
Rape_prod	Rape and turnip rape harvested production (k t)
Rape_price	Rape prices (EUR d kg^{-1})

Source: own elaboration.

RESULTS AND DISCUSSION

Analysis of biodiesel consumption in the EU

In 2010-2013 the consumption of biodiesel in the EU countries exceeded 10.5 M TOE, with 2012 being a unique year when the consumption of biodiesel increased to nearly 12 M TOE. France and Germany are the leaders in the consumption of biodiesel in the EU; their consumption accounts for about 40% of the EU's consumption. In the studied period most member states increased the consumption of biodiesel, with the greater dynamics recorded in two Scandinavian countries, i.e. Sweden and Finland, where it was 172% and 259% respectively. Thanks to a significant increase in the production of biodiesel the countries in the first place achieved the EU objective adopted in the Strategy Europe 2020 assuming a 10% share of biocomponents in liquid fuels (European Commission, 2010) since in Sweden the share in 2013 was 16.7%, while Finland was very close to accomplishing it (9.9%). In turn, for major producers of biodiesel this share is 7.2% in France and 6.3% in Germany. In order to improve the competitiveness of biofuels and support the biofuel industry respective countries make use of subsidies, tax credits and preferential tax rates and introduce limitations on the import of biofuels (Rosiak et al, 2011). However, most EU countries encounter multiple problems implementing the aforesaid, thus in some countries the share of renewable energy in fuels destined for transport purposes is not higher than 1%. This is the case of Spain, Portugal and Estonia.

Analysis of rapeseed market in the EU

In 2010–2013 in the EU countries rape was cultivated over 6673.7 k ha, with the largest area recorded in France (1516.4 k ha) and in Germany (1390.4 k ha) - the total area of rapeseed crops in those countries accounted for 43% of the total area in the EU. In this period the annual yield of rapeseed in the 28 member states of the EU on average amounted to 19979.4 k t, 50.3% of which were crops from France and Germany. Poland and the United Kingdom are also important producers of rapeseed, while countries such as Portugal, Malta and Cyprus do not produce this crop at all. Natural conditions as well as economic and organizational determinants contribute to the differentiation of rapeseed yield, which in the studied years ranged from 17 d t ha^{-1} in Estonia to more than 40 d t ha^{-1} in Belgium and Greece. The prices of the said feedstock on the one hand determine the level of supply of rapeseed and on the other hand - the costs of producing biodiesel from rapeseed oil. The variation in the prices of rapeseed in the EU member states - in 2010-2013 ranges on average from 29.8 EUR d t^{-1} in Spain to more than 40 EUR d t^{-1} in Slovakia, Finland, Sweden, Czech Republic, Germany and Estonia. As it comes to R&D expenditures the Scandinavian countries Finland and Sweden were also the leaders with 2.5 and 2.2 EUR per inhabitant, respectively. A relatively high level of this ratio (about 2 EUR) was achieved also by Denmark, Germany and Austria. The lowest level (not exceeding 0.2 EUR) of R&D expenditures was observed in Cyprus, Greece, Latvia and Lithuania.

Analysis of the relationship between the rapeseed market and the biodiesel consumption

Table 3 contains descriptive statistics and a correlation matrix for the variables included in the model. The first conclusion to be drawn from the data presented is that the consumption and production of biodiesel in the EU countries are strongly differentiated. In addition, the computed correlation matrix for the variables included in the model shows a strong positive correlation between rapeseed production and biodiesel consumption. This relationship directly reflects the production process in which rapeseed oil is used as feedstock for the production of biodiesel. Other correlation coefficients point to moderate positive relations between the variables.

Table 3. Descriptive statistics and correlation matrix for variables

Variable	Mean	Std. Dev.	Min	Max	Skewness	1	2	3
1.Biodisesel_cons.	393.13	606.65	0.0	2268.2	2.04	1.00		
2.Rape_prod	713.55	1355.37	0.0	5784.3	2.53	0.77***	1.00	
3. Rape_price	31.27	15.673	0.0	48.57	-1.20	0.15*	0.23**	1.00

Notes: *** Correlation is significant at the 0.01 level, ** Correlation is significant at the 0.05 level, * Correlation is significant at the 0.10 level
Source: own compilation

Table 4 presents the empirical results of the biodiesel consumption model in the form specified in the equation 1.

The F-test for fixed effects shows that the cross-sectional units don't not have a common intercept. It is important to note that the results of a modified Wald statistic for testing groupwise heteroskedasticity in the residuals of the fixed effects model indicates that we have to reject the null hypothesis of homoskedasticity. To address the residuals heteroscedasticity, we have computed weighted least squares (WLS) estimates, with the weights based on the estimated error variances for the respective cross-sectional units in the sample.

Table 4. Panel model estimates for biodiesel consumption

Variable	Coeff.	Std err.	t- Student	p-value
Const.	103.78	17.87	5.81	<0.00
Rape_price	-3.49	0.66	-5.30	<0.00
Rape_prod	0.35	0.02	18.94	<0.00
Adj. R^2	0,78			
F (9.21)	135.22 (0.00)			
Log-Likelihood	−141.95			
AIC	291.90			

Source: own compilation.

The calculations presented suggest that the variable having the strongest impact on the consumption of biodiesel is the price of rapeseed. The estimated parameters of the model indicate that an increase in the price of rapeseed entails a drop in the consumption of biodiesel. Such a relationship is due to the fact that an important economic factor that determines the use of biodiesel in a given region/area is undoubtedly the cost of its production. The cost of biodiesels varies depending on the feedstock, geographic area, variability in crop production from season to season, the price of the crude petroleum, conversion process or scale of production. For biofuels, a major component of overall costs is the cost of crop feedstock, which as Haas et al (2006) estimate is about 75–80% of the total operating cost. In particular, the cost of producing oil-seed-derived biodiesel is dominated by the cost of the oil and by competition from high-value uses like cooking (Demirbas, 2009). Therefore, high prices of feedstock result in high price of biodiesel, which is twice as expensive as petroleum diesel (Demirbas, 2008).

In the recent literature, the major problem of first generation biofuels, based on the feed stocks, that are used also for food and feed production led to assumption that the correlation between the prices of feedstock and biodiesel consumption is not only unidirectional. The increased food prices coincided with increasing global biofuel production, leading to speculation that biofuel production was responsible for the increased agricultural commodity (feedstock) prices. So far, no significant impact of biofuels production on feedstock prices can be observed (Mueller et al, 2011; Ajanovic, 2011).

Considering the estimated parameters of the model with the variable Rape_prod, it can be concluded that the volume of rapeseed production has a stimulating effect on the consumption of biodiesel. Large production of rapeseed has an effect on increased consumption of biodiesel since the allocation of rapeseed for the purposes of biofuel production is not in conflict with its allocation to food production purposes. Land use competition for production of food and fuel is recently discussed by Rathmann et al. (2010).

The research of Cramon-Taubadel et al (2004) indicate that large agricultural areas may be used for growing those crops, which are necessary for biofuel production without considerable decrease in production volumes for other agricultural products. The production of rapeseed in 2011-2013 increased in the 28 EU member states by 9.7%, reaching 24078.8 k t in 2013. This growth was due to an increase in rapeseed crop yield since the sown area in the years covered by the study changed to a slight extent only and in 2013 was 6708.4 k ha[1]. However, comparing the rapeseed cropping area in 2013 to that in 2008, an increase of more than 9% is noticeable. The official view in the European Commission is that the biofuel target of 10% by 2020 can be met without a serious conflict between land requirements for biofuels or food, although it is anticipated that there will need to be an investment in technology to widen the choice of feedstocks and to continue to partially rely on imports (Summa, 2008). In turn, a modelling study of Wenner and Knibbs (2009) carried out by the REA indicates that by 2020 the EU will need to import the majority of its biodiesel demand, 24–27 T L, unless significant progress can be made in advanced biodiesel from other feedstocks. By 2013 an increase to 5–7 M ha of the EU grown oil seed rape is an estimated maximum area.

Maximum yield output of crops grown for biofuels is just as important as with food or feed crops. In this respect there is little evidence that crops grown for biofuel markets need be managed differently from food or feed crops (Knight, 2010). The used of rapeseed in the biodiesel industry tripled in five years to 20 M t in 2010. It is projected to grow farther, but following recent policy changes, the actual increase may be less than 25 Mt predicted for 2020.

Considering that the paper takes into account only selected determinants of biodiesel production and consumption, the desired line of further studies should be an extension of the scope of the analysed variables.

CONCLUSİONS

The empirical analyses presented in the article point to significant differentiation in the consumption and production of biodiesel and its share in the consumption of liquid fuels in the transport sector in the EU. Among the European countries only Sweden and Finland achieved the EU objective adopted in the Strategy Europe 2020 assuming a 10% share of biocomponents in liquid fuels. In the EU the leaders in biodiesel consumption are France and Germany - their consumption accounts for about 40% of that of the entire EU. These countries are also characterised with the largest area of rape cultivation (43% of the total area in the EU) and the highest annual yield of rapeseed (50.3% of crops in the EU).

The analyses carried out found a strong positive correlation between rapeseed production and biodiesel consumption directly reflecting the production process in which rapeseed oil is used as feedstock for the production of biodiesel. The studies carried out suggest that the variable having the strongest impact on the consumption of biodiesel is the price of rapeseed, which is a statistically significant smaller-the-better characteristic. This observation is consistent with conclusions from the review of literature and results from the fact that the cost of production, predominantly comprising the cost of crop feedstock, is a significant determinant of the consumption of biodiesel in the specific area. It was also demonstrated that the

[1] According to Eurostat

consumption of biodiesel in the EU countries is to a significant extent stimulated by the supply of rapeseed feedstock. An increase in the production of rapeseed has an effect on increased consumption of biodiesel since the allocation of rapeseed for the purposes of biofuel production is not in conflict with its allocation to food production purposes.

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