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Implications of agricultural bioenergy crop production and prices in changing the land use paradigm—The case of Romania

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ABSTRACT

The article starts from the premise that agricultural bioenergy crop production has massive influence in changing the land use paradigm in Romania, due the fact that important land surface areas are cultivated with such crops because of the increasing demand of biofuels. The main aim of the paper is to answer a research question: are there any changes in arable land use patterns determined by the increasing of the agricultural bioenergy crop production and what is the pressure on food consumption? The results show that the competition agricultural vs. energy crops has a considerable impact on land use pattern changes and food security.

1. Introduction

Land requirements for food are determined, among other factors, by population size, demand or the types and amounts of specific foods consumed (Zaharia and Zaharia, 2015) and land requirements for other uses than food. According to the scenario of the United Nations, the world population will grow from 7.2 billion in 2014, to 9.5 billion in 2050 (United Nations, 2014; p. 2). Technological developments and increased global food trade (Popescu, 2015a,b,c) have been the reasons that the agricultural sector is so far capable to keep up with population growth (Ivens et al., 1992). Simulations of agricultural production potentials for the year 2040 indicated that future world populations can be fed (Penning de Vries et al., 1995). As regards the second factor mentioned above, the food consumption patterns involve an efficient land allotment policy in order to fulfill the food demand requirements, taking into account the cultural determinants, the land availability, the weather conditions and the population growth trends.

Numerous studies (Azarhoushang and Rukavina, 2015; Ciutacu et al., 2015; Coyle, 2007; Cobb et al. 1999; Gerbens-Leenes et al., 2002; Schomann, 2015) show that they are probably in the same order of magnitude that changing production levels or the growth of the world population is. The correlation between those two mentioned variables is already proved in literature.

In this paper, the influence of the third factor is analyzed, trying to identify the ways in which the land used for food is affected by land requirements for non-food crops, such as crops used for energy purposes. The issue food vs. biofuels becomes a field of debate because agricultural land is in our days a scarce resource, which should be wisely used, due to the ongoing and dramatic process as industrialization, urbanization or land degradation and desertification which shapes irremediable the old land use paradigms. As (Oldeman, 1992) remarks in this study, since 1945, about 2 billion of the world's 8.7 billion hectares of agricultural land, permanent pastures, and forest and woodlands have been degraded (Oldeman, 1992).

The debates food vs. biofuels reveal wide-ranging views and controversial approaches, in literature (Fletcher et al., 2011; Hussain, 2015; Howe, 2015), which include and it is not limited to some aspects as: the effect of oil price trends on economic development, evolution of the energy balance and energy efficiency usage,

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poverty reduction mechanism, carbon emissions reduction, sustainable biofuel production, soil erosion, biodiversity loss, impact on water resources, food supply shortage, etc. (Fletcher et al., 2011).

There is an increased interest in modeling the effects of biofuels expansion on land use. Mosnier et al. (2013) reveals that renewable fuel standard would substantially increase the portion of agricultural land needed for biofuel feedstock production. Affuso and Hite (2013) developed a mathematical model that simulates a voluntary agricultural program to increase land use efficiency in the production of first generation biofuels in Alabama. Baker et al. (2010) examine environmental and economic implications of carbon reduction policies and the impact of these policies on land use change.

Other discussions go around food prices that were supposed to increase as a result of lower food supply. The influences of the energy crops cultivation on the food products' prices represent a very actual research subject in the context of the actual debate related to the food security and energy independence (Börzel, 2016; Ashford, 2015; Fox and Kenagy, 2015). As it is already shown in recent studies (Kretschmer et al., 2012), the biofuel production has increased the agricultural prices, and a reduction or even abolition of bioefuel demand will reduce the agricultural commodity market price index. Globally, the FAO Food Price Index averaged 208.1 points in February 2014, 195.8 points for cereals, 197.8 points for vegetable oil, 275.4 points for dairy, 182.6 points meat, and 235.4 points for sugar. For example, in 2011 the agricultural prices went up to 230% of its level of 2002–2004 (FAO, 2014).

Also, Glauber (2008) remarks several factors with determinant influence on changing the production paradigm during the translation to the energy crops production, among the most important mentioned are the growing demand for organic food diets, organic agricultural production, the reduction of the cultivated yields due the weather changing conditions, drought, flooding of the agricultural land, lack of the irrigation facilities, increased production costs from energy and fuels. In this context, (Baier et al., 2009) draw attention about the increased production of biofuels, especially of ethanol production which has nearly doubled and biodiesel production which has increased nearly three-fold. This situation reviles a massive shift of the agricultural production toward energy crops, which in the majority of the countries is state subsided and stimulated. For example, in the EU-28 the agricultural land cultivated with energy crops as wheat, barley, and soybeans for biofuels production has constantly increased during the last period as part of the strategy for increasing the European energy independence.

In another study, (Babcock et al., 2010; Babcock, 2011) referring to the influence of the biofuel production on prices mechanism appreciate that it is indisputable that "biofuels contribute to higher agricultural commodity prices because the biofuel industry represents a large and growing share of demand for maize, vegetable oil and sugarcane." (Babcock et al., 2010). On the other side, Kocar and Civas (2013) argue that agricultural lands offer an alternative to the agriculture which is referred to as energy farming.

The biofuel production has been increased and diversified during the years in the majority of the countries, especially in US, Brazil and EU-28. As for example in EU-28, the production of biodiesel was 789,100 tons of oil equivalent in 2001, and few producers decided to convert land from agriculture to energy crops use. It sharply increased in 2012 to 9187,900 tons of oil equivalent (Eurostat, 2014).

Romanian production of biodiesel accounts for almost 1% of European Union production. Still, it increased from 19,600 tons of oil equivalent in 2007 to 88,700 tons of oil equivalent in 2012 (4.5 times). In modern economies, some commodities like maize, sugar cane or vegetable oil (distillated from sunflower, rapeseeds and soybeans) have an wider usage staring as food resources for peoples, feed, or in energy industry for biofuel production.

The idea of studying the biofuels influence on agricultural and food products' prices issued from empirical observations of the fact that, since early 2000, the areas cultivated with energy crops such as rape, sunflower and soybean have continually increased, in Romania, in competition with areas cultivated with cereals. This leads to the question whether changes in land use in the direction of smaller surfaces cultivated with wheat, barley and corn and, as such, lower supply of cereals on the market, influenced the prices of agricultural products and further of food products. The specific objectives of this study are to identify the changes in land use in those regarding the shift from food crops to energy crops and the influence of energy crops' production on agricultural and food products' prices. In order to validate the results, furthermore, the research aims to clarify how strong the correlations are between agricultural and food products' prices and biofuels production.

Starting from the assumption already expressed in literature (Baier et al., 2009) that biofuels have had a massive impact on individual crop prices, and a much smaller impact on global food prices (Baier et al., 2009) we have checked this hypothesis in this paper, considering the case study of Romania (2008–2012). The study analyzes cross-sectional and time series relationships, revealing general trends of agricultural and food products' prices, agricultural land use and agricultural, food and biofuels productions, expressed as econometric functions. These trends provide a better understanding of the connection between agricultural and food prices, and biofuels production. It starts from the assumption that food prices increased as a result of a decreasing supply in the agricultural market, because farmers are responsive to prices (Angus et al., 2009) and so fewer areas are cultivated with wheat, corn, rye, barley for food and feed, and more and more areas are cultivated with energy crops such as rape, sunflower, soybean, for biodiesel, to the detriment of the food supply (climate change is crucial in crop adjustments, having thus a significant impact on biodiversity and food security—considerable alterations in agricultural systems are required in the areas subjected to decisive modifications in climate).

The reasoning of the research goes further to identify the land use implications on food security. The Food and Agricultural Organization (FAO) of the United Nations considers that "food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO website, 2015). This definition has two approaches: quantitative and qualitative. The quantitative one refers to the quantities of food intake needed for a person to have an active and healthy life. Considering that more and more areas are cultivated with energy crops in competition to food, the agricultural supply decreases and, as such, the quantities of food needed to feed the people. The qualitative one refers to the economic access to food, meaning the food is affordable for all people. The recent increases of food prices due to different factors, including competition food vs. biofuels, put pressure on people's economic access to buy the food needed for an active and healthy life, and therefore on food security.

The level to which the advancement of biofuels participates in contest with food production, bringing about aspects of food security, relies on a diversity of elements: selection of feedstock; natural resources (chiefly land and water) entailed; relative efficiencies (GHG releases, yields, expenditures) of various feedstocks; and processing technologies chosen. The demand to adapt biofuel schemes to their consistency with food security as a main policy goal, in addition to environmental interests and the requirement to indicate adequate GHG savings, functions as powerful determinants for a fast shift to second-generation biofuels. Governments alter biofuel schemes, design and systematize buffering mechanisms lest biofuel need does not pose a menace to food security from price increases. Biofuel development brings out the demand for more unified land-use schemes, considering the diverse uses of land and their relevance to food security (HLPE, 2013).

2. Current status of biofuels production in European Union

The European Union elaborated a strategy for biofuels in February 2006 (*An EU strategy for biofuels, Official Journal C 67, 18.3.2006*). In its strategy, the Commission defines the role that biofuels produced from biomass, a renewable resource, may play in the future as a source of renewable energy serving as an alternative to the fossil fuel energy sources used in the transport sector. The European Union creates a Community framework to promote the use of biofuels in order to reduce greenhouse gas emissions and the environmental impact of transport, and to increase security of supply.[1] Table 1 presents the dynamics of EU biodiesel production in some EU-28 countries, 2007–2013 (% in EU-28).

According to the EU legislation, each Member State must ensure a determinant quota of biofuel with the minimum share of biofuels sold on inland markets, which was established at 5.75%. Any Member State which does not comply with the EU regulation and setts lower objectives must justify their decision on the basis of objective criteria. Directive 2003/30/EC was repealed by Directive 2009/28/EC with effect from 1 January 2012. As a result, year by year, the production of biodiesel, the most common biofuel in Europe, increased. According to Eurostat (2014) and USDA FAS data (2012), in EU-28, the production of biodiesel was 9187,900 tons of oil equivalents, in 2012, 11 times higher than its level in 2001. The main producers are: Germany (27%), France (21%), and the Netherlands (11%). Romania accounts for almost 1% of the European Union production of biodiesel. Production of biodiesel sharply increased in 2011 to 8493,5 1000 tons of oil equivalent to 9868.5 tons of oil equivalent in 2013. (Eurostat, 2014)

Sobrino et al., 2010 notice that for several years the European Union has had an active policy in promoting biofuels production in order to reduce the energy dependence from foreign imports and also for increasing the rural and agricultural revenues taking into account that biofuels are raw materials including crops and vegetables. (Table 2)

Prices have been updated using inflation. Prices of agro-food products increased in 2013 compared to 2007 for all products, excluding maize, poultry meat and sheep milk. 2013 was declared a good agricultural year regarding yields and production. This leads to the idea that, when production increases, prices decrease. Reduction in maize prices could be a result of increased supply. With respect to this hypothesis and considering the fact that data for biodiesel production are not available for 2013, the period 2007–2012 is analyzed. Additionally, poultry meat and sheep milk are excluded, because their prices decreased in the period analyzed and results are not relevant for this piece of research. Prices of agricultural and food products are influenced by supply and demand. This research studies how prices are affected by supply (Mulligan, 2015; Lavinas, 2015). In this respect, the production, as main part of supply, for agricultural and food products are analyzed, starting right from the areas cultivated and livestock. Thus, conclusions regarding land use changes can be drawn.

3. Current status of land use in Romania

Agriculture is the largest type of land use in Romania. In 2012, 14,615.1 thousand hectares, approximately 61.3% of the total area of Romania (23,839.1 thousand hectares) was used for agricultural purposes (NIS, Statistical Yearbook, 2013). Table 3 shows current agricultural land use in Romania. About 64% of agricultural area is associated with arable cropping, and about 22% with grassland, mostly permanent pastures. Hayfields occupy about 6% of the total agricultural area. Vineyards and orchards account for 1.4% and, respectively, 1.3%

Table 3 shows the dynamic of agricultural land use in Romania, between 2007 and 2012. The proportion of the land area used for agricultural purposes has declined steadily over the last five years, mainly in response to demands for other uses, predominantly urban. There was a small increase in hayfields use, but all other uses slightly decreased.

Table 3 shows changes in the distribution of crops, in the period 2007–2012, reflecting the fact that the largest areas are cultivated with corn. In Fig. 1 we present the evolution of the surfaces of wheat, barley, oatmeal, maize, sunflower and soybean during 2008–2012 (2007 = 100). Areas cultivated with sunflower grew up in 2012 and area under rape sharply increased in 2010, and decreased afterwards. Areas under cereals: wheat, barley, oatmeal and maize remained around the same values in the period analyzed. (Gerbens-Leenes et al. 2012) accentuates the dependence between biofuel production and crops production, saying that the transition to biofuels requires the production of more crops. Depending on the location, countries choose different crops. Because corn is the most important crop as regards cultivated area, the analysis go deep to see the proportions of the areas cultivated with other cereals and oilseeds in the area cultivated with corn (Table 4). As concerning livestock, the dynamics has registered some decreases as it is shown in Fig. 2. Pig and poultry numbers have decreased rapidly over the period indicated in Fig. 2, largely as an effect of high feed prices, disease outbreaks and the cost of implementing new welfare standards for animals, after Romania accession to EU (Statistical Yearbook of Romania, 2013). The increase in cattle, sheep and goats is a result of changing consumers' diets, with sheep and goat milk becoming more popular than cow milk and beef meat more popular than pig meat with Romanian consumers.

Production of agricultural and food products, as the main component of supply on the market, is studied because of its influence on prices. In Table 5, the dynamics of data regarding production of the broad agro-food products is presented.

As seen in the table above, productions of vegetable origin have varied much in the period analyzed, as a result of oscillations in cultivated areas and yields, the latter being under the high pressure of weather conditions. Total productions of wheat, barley, maize went down in the last statistical year, 2012, which leads to the assumption that prices went up as a result of decrease in supply. Sunflower production increased 3.27 times in 2011 compared to 2007, because of larger areas cultivated and higher yields. Rape production was 3 times higher in 2010 compared to 2007, and decreased afterwards, as a result of decreasing area under rape. It seems that farmers, after low price obtained in 2011 for rape because of high supply, decided to rethink the structure of production and renounce, for a while, to rape. Production of animal origin did not vary much in the period analyzed, absorbing the shocks of agricultural market as a bull whip effect.

4. Data and methods

Many detailed studies estimating the impact of the rise in biofuels production on crop and food prices are available. This piece of research focuses on the increase in biofuels production on crop prices for wheat, barley, oatmeal, corn, sunflower, soybeans and sugar beet, as well as food prices for poultry and pork meat, beef, and cow and sheep milk. Prices have been gathered from

[1] Feedstocks used for biodiesel production includes large types of animal fats, vegetable oils, soy, rapeseed, mustard, flax, sunflower, palm oil, hemp. The main types of biofuels includes: bioethanol, biodiesel, ETBE, biogas, biomethanol, methanol, bio-oil.

Table 1
Evolution of EU biodiesel production in some EU-28 countries, 2007–2013.

Country	% in EU-28						
	Year						
	2007	2008	2009	2010	2011	2012	2013
Belgium	2.38	3.77	2.79	3.19	3.03	2.92	2.69
Bulgaria	0.00	0.13	0.13	0.12	0.17	0.08	0.40
Czech Rep.	1.35	1.02	1.71	1.96	2.19	1.66	1.63
Germany	49.21	33.49	26.94	30.62	32.05	27.06	27.03
Ireland	0.41	0.57	0.72	0.71	0.28	0.26	0.22
Spain	3.02	2.97	8.14	8.45	7.17	4.83	6.55
France	16.36	23.86	23.54	20.18	19.16	21.23	19.52
Italy	3.34	8.84	8.80	7.90	6.15	2.75	4.11
Latvia	0.15	0.37	0.50	0.43	0.63	0.87	0.59
Lithuania	0.41	0.86	1.15	0.88	0.83	1.02	1.05
Hungary	0.15	1.84	1.40	1.42	1.50	1.40	1.27
Netherlands	1.40	1.10	3.02	3.78	5.11	11.29	12.31
Austria	4.24	3.28	2.92	2.71	2.45	2.24	1.56
Poland	0.81	3.56	4.17	3.90	3.92	6.03	5.86
Portugal	2.98	2.16	2.77	3.13	3.80	2.92	2.68
Romania	0.37	1.22	0.90	0.12	1.11	0.96	1.22
Slovakia	0.83	1.51	1.24	1.25	1.35	1.08	0.96
Finland	0.69	1.26	2.87	3.33	2.37	2.76	3.20
Sweden	1.92	1.95	2.02	1.99	2.74	3.64	2.22
UK	7.10	3.75	2.18	1.53	1.85	2.38	2.38

Source: authors' own computation based on Eurostat (2014).

Table 2
Evolution of agricultural and food products prices, in Romania, 2007–2013 (Euro/kg, Euro/liter).

Product	2007	2008	2009	2010	2011	2012	2013	Index 2013/2007
Wheat	0.196	0.203	0.134	0.159	0.224	0.219	0.198	101.0
Barley	0.235	0.273	0.174	0.173	0.234	0.243	0.251	106.8
Oatmeal	0.245	0.313	0.199	0.216	0.287	0.291	0.261	106.5
Maize	0.248	0.298	0.191	0.192	0.254	0.250	0.233	94.0
Sunflower	0.271	0.344	0.245	0.321	0.402	0.442	0.370	136.5
Soybean	0.251	0.298	0.273	0.332	0.331	0.411	0.426	169.7
Pork meat	1.143	1.422	1.453	1.330	1.325	1.459	1.433	125.4
Poultry meat	1.073	1.048	0.988	0.863	0.903	0.848	1.005	93.7
Cow milk	0.419	0.488	0.550	0.531	0.539	0.546	0.491	117.2
Sheep milk	0.386	0.452	0.402	0.399	0.460	0.449	0.372	96.4
Beef	0.960	1.081	1.364	1.308	1.401	1.332	1.396	145.4

Source: authors' based on NIS (2014).

Table 3
Agricultural land uses types in Romania, in 2007–2012 ('000 ha).

Specification	2007	2008	2009	2010	2011	2012	2012/2007 (%)
Agricultural area	14,709.3	14,702.3	14,684.9	14,634.5	14,621.5	14,615.1	99.4
Arable	9,423.3	9,415.1	9,422.5	9,404.0	9,379.5	9,392.3	99.7
Pastures	3,330.0	3,333.0	3,313.8	3,288.7	3,279.3	3,270.6	98.2
Hayfields	1,531.4	1,532.4	1,528.0	1,529.6	1,554.7	1,544.9	100.9
Vineyards and vine nurseries	218.0	214.5	215.4	213.6	211.3	210.5	96.6
Orchards and tree nurseries	206.6	207.3	205.2	198.6	196.7	196.8	95.3

Source: authors' based on NIS (2014) and MADR (2014).

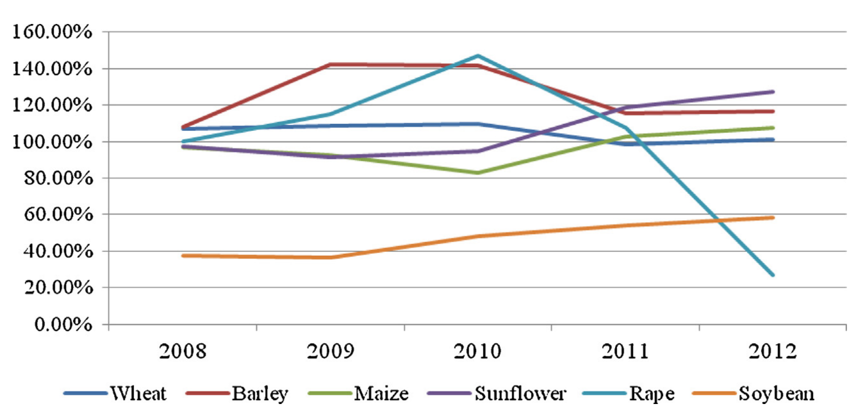


Fig. 1. Evolution of the cultivated area, by main crops, in Romania, 2008–2012 (2007 = 100)
Source: authors' own computation based on NIS, (2014), and MADR (2014).

Table 4
Cultivated area, by main crops, in Romania, as proportion of the area cultivated with corn, 2007–2012.

Crop	2007	2008	2009	2010	2011	2012
Wheat	0.78	0.86	0.92	1.03	0.75	0.73
Barley	0.14	0.16	0.22	0.25	0.16	0.16
Oatmeal	0.08	0.08	0.09	0.09	0.08	0.08
Maize	1.00	1.00	1.00	1.00	1.00	1.00
Sunflower	0.33	0.33	0.33	0.38	0.38	0.39
Rape	0.14	0.15	0.18	0.26	0.15	0.04
Soybean	0.05	0.02	0.02	0.03	0.03	0.03

Source: authors' based on NIS (2014) and MADR (2014).

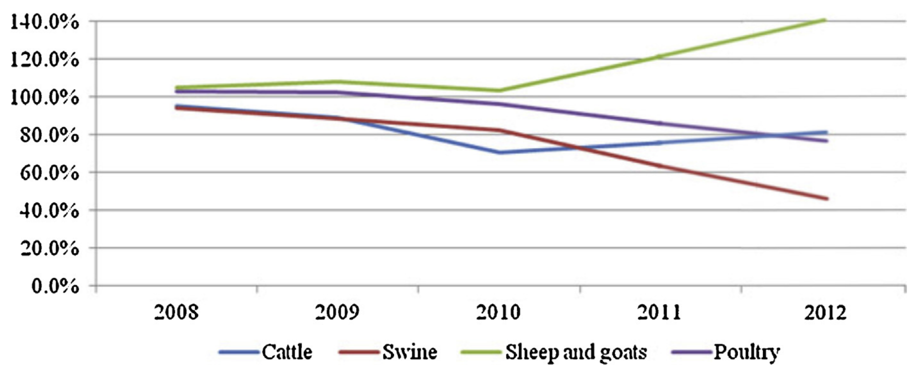


Fig. 2. Evolution of livestock, in Romania, 2008–2012 (2007 = 100)
Source: authors' own computation based on NIS, (2014), and MADR (2014).

Table 5
Production of the main agricultural and food products in Romania, 2007–2012 (thousand tons).

Product	2007	2008	2009	2010	2011	2012
Wheat	3,044.5	7,181.0	5,202.5	5,811.8	7,131.6	5,297.7
Barley	5,31.4	1,209.4	1,182.1	1,311.0	1,329.7	986.4
Maize	3,853.9	7,849.1	7,973.3	9,042.0	11,717.6	5,953.4
Sunflower	546.9	1,169.7	1,098.0	1,262.9	1,789.3	1398
Rape	361.5	673	569.6	943	739	157.5
Soybean	136.1	90.6	84.3	149.9	142.6	104.3
Pork meat	642	605	585	553	595	601
Poultry meat	416	410	489	446	468	475
Cow milk[a]	54,875	53,089	50,570	42,824	43,807	4,295
Beef	333	306	264	205	289.3	301.8

Source: authors' based on NIS (2014) and MADR (2014).
[a] Thousand hectoliters.

the National Institute of Statistics of Romania. Data base includes biodiesel production, as the main biofuel, in Romania, starting in 2007, when the production of biodiesel becomes significant, and ending in 2012, the last statistical year. The prices for agro-food products, the agricultural areas cultivated in Romania with crops mentioned above and with energy crops, and their production are analyzed in the same period. Series data have been collected from the Romanian Statistical Yearbook and Eurostat. The correlation coefficients of variables were computed and tested using ANOVA program (Annexes 1 and 2).

Biomass energy crops can be divided into short rotation energy crops that are harvested on a cycle of 2–20 years, depending on the crop and the system, and herbaceous energy crops that are harvested annually. Such crops are: rape, sunflower and soybean. These products are considered to this piece of research, because they represent the main source of biodiesel in Romania and the main substitute of agricultural crops such as wheat, barley, corn, oatmeal, and other cereals, whose main destination is human and animal feed.

This study identifies the agricultural and food prices trends in Romania in the last years. These trends provide a better understanding of agro-food prices and biofuels supply connection. We assume that when production of biofuels increases, agricultural and food prices rise, because supply of agricultural products decreases as a result of energy—agricultural crops competition. Despite this, Zhao et al. remark that plant biomass can contribute to a stabilization of farmers' incomes, and can maintain and improve ecological and social sustainability (Zhao et al., 2009).

5. Results and discussions

This research emphasizes whether there are any changes in arable land use that put pressure on food consumption, assuming the premise that cereal production decreases as a result of the fact that energy crops are cultivated on larger areas because of the increasing demand of biofuels. As a result, lower areas cultivated with cereals means lower levels of output and higher prices for cereals, which leads consumers to rethink their food consumption in quantitative and structural approaches. This premise is validated by identifying whether there are correlations between biofuels production and agricultural and food prices and how strong they are.

Thus, data regarding production of biodiesel, as the main biofuel in Romania, and prices of agricultural and food are considered for computation in Table 6. The coefficients of correlation, determina-

Table 6
Coefficients of correlation, determination and standard error for production of biodiesel and agricultural and food prices.

Product	Coefficient of correlation	Coefficient of determination	Standard error	Regression equations
Wheat	0.736	0.546	0.026	$y = 0.1596 + 0.0007x$
Barley	0.388	0.153	0.041	$y = 0.2043 + 0.0004x$
Oatmeal	0.574	0.33	0.041	$y = 0.2290 + 0.0007x$
Maize	0.328	0.107	0.043	$y = 0.2237 + 0.0004x$
Sunflower	0.853	0.728	0.044	$y = 0.2651 + 0.0017x$
Soybean	0.697	0.486	0.045	$y = 0.2717 + 0.0010x$
Pork meat	0.237	0.056	0.129	$y = 1.3233 + 0.0007x$
Cow milk	0.422	0.178	0.051	$y = 0.4880 + 0.0006x$
Beef	0.502	0.252	0.171	$y = 1.1403 + 0.0024x$

Source: authors' own computations based on Table 2.

tion and standard error for production of biodiesel and agricultural and food prices are calculated using computer programs of simple regression.

Correlations have been identified between biodiesel production and prices of wheat, oatmeal, sunflower, and soybean. Prices of barley, maize, pork meat, cow milk and beef are not correlated to biodiesel production, and thus the prices of these products are influenced by other factors: market demand, costs of input etc. Coefficients of determination show that influence of production of biodiesel on agricultural prices is significant for wheat and sunflower (over 50% of observations). These results lead to the conclusion that biofuels demand has low influence on agricultural and food prices, in Romania, and that prices are influenced by many other factors. As Sage (2013, p. 72) puts it, "the most significant drivers of food price volatility are: financial speculation; climate change and extreme weather; energy prices and the expansion of the biofuels sector; declining grain stocks; a drastic fall in public investment in agriculture over two decades; and rising consumer demand, both demographic and changing dietary composition". In some regions, where production of biodiesel is more developed than in Romania, biofuels have important influence on prices, as Evans (2009) noticed, for UK, that no less than three quarters of the 140 per cent increase in food prices index from 2002 to 2008 was caused by biofuels and related effects.

The results show stronger correlation between biodiesel production and agricultural prices than between biodiesel production and food prices, meaning that markets of final consumer (food markets) absorb the shocks of agricultural market in those regarding price volatility.

These outcomes have been found out also by other authors (e.g. Swinton et al., 2011) who notice that if biomass profitability rises relative to the other crops, the first-round effect will be to compete for the cropland. But the second-round effect is that as markets respond, conventional crop prices will raise, potentially eroding the first-round profitability advantage of biomass crops. The findings confirm what other authors discovered: Piroli et al. (2012) found out that markets for crude oil and cultivated agricultural land are interdependent: an increase in oil price by 1 dollar/barrel increases land use between 54,000 and 68,000 ha. Also, the increase of bioenergy sector accelerates land use change in the US, i.e. food commodities are being substituted for bioenergy crops.

On the short run, weak correlations between productions of biodiesel and agricultural and food prices mean that increasing demand of biodiesel does not put pressure on food security in Romania. There are other challenges too to assuring food security and sustainable use of natural resources: widespread poverty and inadequate human resource development in rural areas; increases in populations, especially in urban areas, which will substantially increase food needs; incapacity of farmers to access European Union funds; inadequacies in availability of and access of small farmers to agricultural inputs: fertilizers, pesticides, energy, research, and technology, degradation of natural resources, which all undermine production capacity; unorganized activities, relationships and operations of agents along agricultural chains; insufficient developing of collecting agricultural output from small and numerous farmers etc.

Pinstrup-Andersen and Pandya-Lorch, (1998) considers that some of the challenges of food security can be overcome if all relevant parties – individuals, households, farmers, local communities, civil society, private sector, national governments, and the international community – take appropriate action and change their behavior, priorities, and policies.

On the long run, the implications of biofuels production on land use and food security will be stronger (Peters and Heraud, 2015), due to rising energy costs, given the anticipated decline in conventional oil supplies which will have repercussions for land-use and food security in the direction of changing the uses of land from cereals to energy crops.

6. Conclusions

Lately, the Romanian government's endeavors to enhance worldwide food and nutrition security have been fostered, but the advancement can be made only with substantial responsibilities from civil society, research entities, private sector, and farmers. Legislation should include a thorough, sustainable proposal to agricultural enhancement, and food and nutrition security. Also, a law which would compel supermarkets to hand out surplus but safe food to charitable entities is required. Normative initiatives have also been furthered recently regarding the large regions impacted by agricultural abandonment, mainly a consequence of downturn in the practicality of broad (low input) and limited agricultural systems.

We may conclude that energy markets are placed in competition with food markets for scarce arable land, resulting in higher agricultural prices. A final answer to the research question is that, overall, the competition agricultural vs. energy crop has a considerable impact on land use and food security, because significant correlations have been identified between production of biodiesel and price of wheat, the latter as main cereal designed to human consumption and animal feed (Popescu-Ljungholm, 2015). Agricultural prices are more influenced by biofuels production (except barley and maize), whereas food prices are less impacted by it. Strong correlations have been identified between prices of wheat, sunflower and soy bean and production of biodiesel. Weak correlations have been identified between prices of pork meat, maize and barley and production of biodiesel, meaning that prices are influenced by other factors and biodiesel production is not so developed in Romania, yet in a level that would put pressure on food security. We do not claim that production of biofuels is the only factor determining food prices increase, nor that this situation will last over the long run. Future research should study to what extent prices of agricultural and food products are influenced by production of biodiesel, and to identify the form of econometric functions between them. Raising biofuel production will have a considerable effect on international agricultural commodity prices and food security. The EU-28 plan for the restriction of food-based biofuels has stemmed from the threat of the impact of *indirect land-use change* on GHG release reductions: the restriction can be instrumental in diminishing market constraint for food markets and can be partly responsible for a fortification of international food security (the related effect on food security and the natural world can be generated by *direct and indirect land -use change*). International food-based biofuels may have a detrimental effect on food security on a worldwide level: biofuel spread may have generated a boost in agricultural commodity prices and in food ones, influencing the global food security negatively (food price volatility has weakened nutritional standing and food security) (Koizumi, 2014).

The direct impact on land use change has been captured by other authors as well (e.g. Piroli et al., 2012): the agricultural land conversion to producing bioenergy crops, i.e. biofuel support policies cause substitution in land use between different types of agricultural crops. In Romania, areas cultivated with rape continuously increased until 2012, replacing areas dedicated to cereals. The indirect impact on land use paradigms is the expansion of the energy crops allotment in the total agricultural area, by attracting new land in production, not previously used for agricultural production which now is converted into farmland. The financial support for energy crops production is also an determinant factor in promoting this shift.

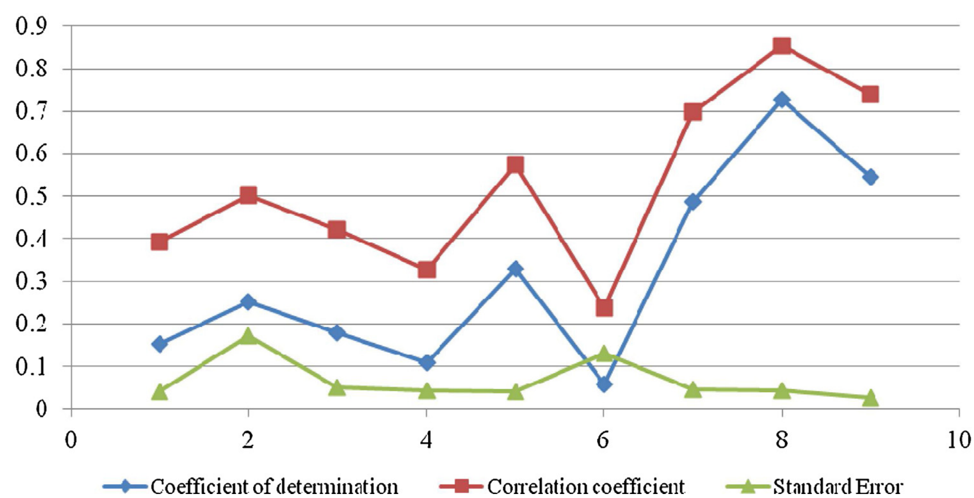
This land extension could represent a solution for increasing biofuels production without compromising areas dedicated to food, by cultivating energy crops on other land than areas occupied with cereals or vegetables. As Swinton (2011) observed, by expanding energy biomass production on marginal lands that are not currently used for crops, food prices increase and indirect climate change effects can be mitigated. In Romania, 24% of the arable land is uncultivated, which offers the opportunity of growing energy crops, and 32% of agricultural land is occupied by pastures and hayfields, whereas parts of them can be attracted to arable use for energy crops cultivation. Furthermore, incentives should be provided to farmers and local communities to invest in and protect natural resources, and to restore degraded lands.

In the future, the impact of biofuels on land use and food security is expected to be weaker, because there are efforts underway to develop so-called 'second generation' cellulosic biofuels and even third generation using algae (Murphy, 2010), or stronger, if energy costs will continue to grow and will require alternative energy supply, including biomass and biodiesel, which will put pressure on arable land used for human consumption. The present paper analyzes the land use changes as a result of land requirements for other uses than food. But land use is determined by other important factors too, such as demand for food and population size, which are not analyzed. Also, as (Kupchan, 2015; Willow and Keefer, 2015) argues "high agricultural commodity prices are not caused solely by expanded biofuels demand. Elements as economic crisis, strong food demand growth, and weather-related supply problems have contributed massively to high prices evolution in the last decades.

This is not the case of the present study, but of further research. This study adds value to previous investigations, showing the implications of the shift from food crops to energy crops, and the influence of energy crops and biofuels production on agricultural and food products' prices in Romania. Although many studies are available worldwide, none of them refers to Romania.

Annex 1.

The correlation coefficients of variables tested using ANOVA program.



Source: authors' own computation.

Annex 2.

The ANOVA results.

	Source of Variation		ss	df	MS
Barley	Regression		0.001	1	0.001
	Residual		0.007	4	0.002
	Total		0.008		
	F^* =	0.725			
	Mean Absolute Deviation (MAD)				

Beef	Regression		0.040	1	0.040
	Residual		0.118	4	0.030
	Total		0.158	5	
	F^* =	1.353			
	Mean Absolute Deviation (MAD)	0.1435			
Cow milk	Regression		0.002	1	0.002
	Residual		0.011	4	0.003
	Total		0.013	5	
	F^* =	0.868			
	Mean Absolute Deviation (MAD)	0.0383			
Maize	Regression		0.001	1	0.001
	Residual		0.008	4	0.002
	Total		0.008	5	
	F^* =	0.483			
	Mean Absolute Deviation (MAD)	0.0333			
Oatmeal	Regression		0.003	1	0.003
	Residual		0.007	4	0.002
	Total		0.010	5	
	F^* =	1.972			
	Mean Absolute Deviation (MAD)	0.0284			
Pork meat	Regression		0.004	1	0.004
	Residual		0.067	4	0.017
	Total		0.071	5	
	F^* =	0.240			
	Mean Absolute Deviation (MAD)	0.1061			
Soybean	Regression		0.008	1	0.008
	Residual		0.008	4	0.002
	Total		0.016	5	
	F^* =	3.793			
	Mean Absolute Deviation (MAD)	0.0393			
Sunflower	Regression		0.021	1	0.021
	Residual		0.008	4	0.002
	Total		0.028	5	
	F^* =	10.704			
	Mean Absolute Deviation (MAD)	0.0412			
Wheat	Regression		0.003	1	0.003
	Residual		0.003	4	0.001
	Total		0.006	5	
	F^* =	4.823			
	Mean Absolute Deviation (MAD)	0.0199			

Source: authors' own computation.

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