GREENHOUSE GAS EMISSIONS FROM AGRICULTURE: A COMPARATIVE ANALYSIS BETWEEN COUNTRIES THAT RECENTLY JOINED THE EU

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ABSTRACT: The global climate changes are determined by diverse causes and among these, greenhouse gases emissions from business activities and agriculture, are partly responsible. The consequences of global climate changes are dramatic not only for the environment, and implicitly for the quality of life, but also for business activities, which must adapt to meet this challenge. Therefore, reducing greenhouse gas emissions is an objective aimed through international protocols by all the countries of the world. This study examines the contribution of newest EU members' agriculture to the emissions of greenhouse gases. The analysed data show the strong, direct and positive connection between agricultural activities and GHG emissions. The emission intensity caused by the agriculture of the countries that recently joined the EU is higher than the EU-27 average, that's why these states should consider the option to develop sustainable agriculture, which will control and reduce this phenomenon and prevent its negative impact.

Keywords: climate changes, greenhouse gas emissions, agriculture, regression analysis

JEL Codes: O13,Q57

Introduction

At the beginning of the millennium, mankind's development and consumption patterns have became major concerns regarding the rationality in resources exploitation and in preservation the equilibrium between economic, social and natural environment. Human interventions in the ecosystems have been speeded, and nowadays we are confronted with unprecedented environmental issues as, pollution of soils and water, atmospheric pollution, loss of the biodiversity etc. Also climate change (global warming) is one of the most important and profound environmental issues facing the planet.

The causes of the climate changes are very complex and for this reason they are a vast research subject, often providing contrary conclusions. Before the 1850 the changes of the climate had been provoked by the natural causes as, changes in solar irradiance and volcanism (Crowley, 2000). Milanković theory shows that variations in the obliquity and precession of Earth‘s rotational axis, and variation in the eccentricity of the orbit determined Earth's climatic change (Wieczorek, 2008). From the mid-nineteenth century the human activity is the main cause for warming of the Earth due to changes in land use and land cover (LULCC), including the burning of the fossil fuels, agriculture and deforestation. This has contributed to a rise in greenhouse gases (GHG) in the atmosphere, which also seems to be the dominant cause of the climate changes over the next few decades (IPCC, 2007b).

In Europe, the reducing of greenhouse gases is a key point for the sustainable growth. In order to reduce atmospheric emissions all areas of the economy which produce carbon dioxide and other greenhouse gases must be looked at and this includes agriculture.

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The primary greenhouse gases produced by agriculture are methane (CH4), nitrous oxide (N2O) and carbon dioxide (CO2). Methane and nitrous oxide have a high global warming potential, which leads to significant climate changes that have negative effects on the environment and, implicitly, on the quality of live.

In the European Union, in 2010 greenhouse gases emissions caused by agriculture represented an average of 9.8% of total emissions. The sources of GHG emissions in agriculture are various: direct energy use, fertilizer application, digestion by ruminants, manure management methods, crop residues burning, etc.

The Kyoto Protocol aims to reduce GHG emissions by at least 5% by 2012 compared with 1990 levels. The United Nations Climate Change Conference took place in Copenhagen (2009) and acknowledged this target as “one of the greatest challenges of the present day”, proposing further reduction of GHG. The European Union has proposed a greenhouse gas reduction of at least 20 percent until 2020. To achieve these national objectives, the national strategies include concrete measures to reduce greenhouse gases for all economic activities.

In line with this, one of the most important tasks of agriculture in each country is to provide food security. The challenge faced globally by the agricultural sector is to harmonize the contradiction between the growing demand of agricultural products caused by population growth and urbanization and the containment of the negative effects of production activities on the environment.

The necessary changes in the management of agricultural activities require several concerted strategies, efforts and actions to meet the three dimensions of sustainable development. First, agriculture should provide specific agricultural products in terms of economic efficiency and thus contribute to the biologic and economic support of the population. In terms of environmental restrictions, the tasks of this sector should aim to avoid the degradation of the natural ecosystems, maintaining biodiversity and managing natural resources better.

The present paper examines the contribution of agriculture to the emissions of greenhouse gases for the countries that recently joined the European Union (Czech Republic, Cyprus, Estonia, Hungary, Malta, Latvia, Lithuania, Poland, Slovenia, Slovakia, Romania, Bulgaria). This paper used specific methods for the statistical and econometric analysis and the information was taken from the database of the European Union (Eurostat).

The results for the years 1996-2010 show the impact of agriculture on air pollution emissions, as well as the law of manifestation of the dependence between GHG emissions and agricultural activities in the countries that recently joined the EU. The conclusions show the necessity to adopt measures to reduce agricultural GHG emissions by the newest member states, as well as by the other European countries. This is a way to mitigate climate changes, as well as a method for sustainable development of an important component of the EU economy.

The Convention on Climate Change has called for the past 20 years to stabilize GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (UNFCCC, 1992). The European Parliament’s Environment Committee suggested that industrialized countries, which are the biggest polluters, should contribute to reducing emissions by 20% by 2020 compared to 1990. The necessary measures that must be taken to reduce air pollution aim issues regarding adaptation, mitigation, technology, capacity-building, reducing emissions. The decisions made for this purpose are also a way to achieve the ideal of climate-friendly and resource-efficient in Europe (Fischer and Leinen, 2010).

Recent literature includes numerous studies about agriculture and examines the potential of agricultural system to reduce polluting emissions. Analyses show GHG emissions and other forms of environmental degradation that result from the production of crops (Snyder et al., 2009; Smith et al., 2007), bio fuel crop production (Menichetti et al., 2009; Delluchi, 2010; Schneider et al. 2003), animal production (Avery and Avert., 2008; Koneswaran and Nierenberg, 2008) .

Other studies analyze the possibilities to implement agricultural production systems that have low impact on GHG emissions, referring particularly to the advantages provided by organic agriculture (Niggli et al., 2009, Muller and Davis, 2009). It is believed that due to the features of organic agriculture, it is a type of economic activity with favourable impact on the GHG level, its potential to reduce total greenhouse gas emissions being estimated at 9-13% (Muller and Davis, 2009).

Therefore, the results of the analyses suggest the need for immediate changes in agricultural technologies and consumption patterns and their conversion towards practices that are characteristic to sustainable agriculture, which can limit the impact of GHG emissions and climate change. In this sense, in the new countries joined the EU, the sustainable agriculture could be a chance for the farming development. In the EU's documents regarding the implementation of common agricultural policy (CAP) it is stipulated that investments in the environmental performance of farms lead to efficiency gains in production so that the competitiveness in the sector should increase (EC, 2006; COM, 2012).

The studies on the contribution of EU agriculture to GHG emissions targeted, among others, the following: regionalized inventory of biogenic greenhouse gas emissions (Freibauer, 2003), the assessment of marginal abatement costs for agricultural emissions at the farm, regional and country level of the EU 24 (De Cara and Jayet, 2009), emission trading scheme (Perez Dominguez et al., 2009) etc. But these studies contain little information about the contribution of the agriculture in the 12 countries that recently joined the EU. These countries have developed agriculture and significant GHG emissions. This is why a comparative analysis between the emission level in these countries and EU-27 can highlight interesting aspects.

Contribution of agriculture to GHG emissions

Agriculture has an important role in the economy of the European Union. It ensures food security, the stability of society, preservation of the environment and the development of rural economy.

Reducing the share of agriculture to GDP is a consequence of the economic progress, which led to the development of other activities that produce goods and services. In EU-27, the contribution of agriculture to gross value added (GVA) dropped from 2.4% in 1999 to 1.8% in 2008 (table 1). This trend is present also in countries that recently joined the EU at various intensities. In Bulgaria and Romania, the contribution of agriculture to GVA dropped by half (from 15.9% to 6.9%, and 14.4% to 7.4% respectively). These two countries have the higher share of GVA by agriculture of all branches in 2009.

The development of agriculture is often accompanied by negative phenomena also: soil pollution, particularly due to the use of synthetic chemical substances for plant protection treatments, artificial fertilization of soils, plant and animal residue discharge; air pollution through crop treatments; water pollution, etc.

A major problem faced by European agriculture is the need to adapt it to climate change. The consequences of climate changes on agriculture are complex and often negative. These will affect the volume, quality and stability of food production and the natural environment in which agriculture takes place. Climatic variations will have consequences for the availability of water resources, pests and diseases and soils, leading to significant changes in the conditions for agriculture and livestock production. In extreme cases, the degradation of agricultural ecosystems could mean desertification, resulting in a total loss of the productive capacity of the land in question (EC, 2009).

At the same time, agriculture is largely responsible for climate changes caused by greenhouse gas emissions: methane (CH_4), nitrous oxide emissions (N_2O) and carbon dioxide (CO_2).

Table 1 shows that in 2010, GHG by agriculture represents 9.8 % of total EU-27 emissions (against 10,1 % in 1999).

Table no. 1.

Agriculture and polluting emissions, 1999-2010

EIT countries of EU	Gross value added by agriculture and fishing, % of all branches			GHG by agriculture, % share of total GHG emissions		
	1999	2004	2010	1999	2004	2010
Bulgaria	15.9	10.7	5.3	11.0	10.3	10.4
Czech Republic	3.7	3.2	2.3	6.6	5.8	5.6
Estonia	4.4	3.9	3.5	7.4	6.6	6.6
Cyprus	4.0	3.0	2.3	7.4	7.0	6.2
Latvia	3.9	4.4	4.1	18.1	18.7	19.3
Lithuania	7.3	4.6	3.4	19.9	20.0	21.4
Hungary	5.9	4.9	3.5	11.9	11.9	12.2
Malta	2.7	2.7	1.9	3.5	3.3	2.6
Poland	5.2	5.1	3.5	9.1	8.6	8.6
Romania	14.4	14.1	6.5	13.5	11.9	13.8
Slovenia	3.3	2.7	2.4	10.9	10.0	10.1
Slovakia	4.7	4.1	3.9	6.7	6.2	6.7
EU 27	2.4	2.1	1.7	10.1	9.4	9.8

Source: Eurostat

In 2010, the joint contribution of EIT counties' agriculture to total GHG emissions was under the share of the whole European Union (9.5%). These 12 countries have jointly discharged 877583 thousand tonnes CO^2 equivalent, which represents a share of agricultural GHG of approximately 1.8% of total GHG emissions at the level of the whole EU.

The GHG emissions in agriculture have different shares in total emissions released by the newest EU members. In 2010, Malta (with the lowest share of 1.9%), Czech Republic, Slovakia, Estonia, Cyprus, Poland recorded values below the EU average, while states such as Bulgaria, Lithuania (with the highest share of 21.4%), Latvia, Romania, Slovenia and Hungary exceeded the average.

The scenarios regarding the agriculture-environment relationship show that the increase of the agricultural production is accompanied by an increase of GHG emissions. (Smith et al. 2007).

For the countries that recently joined the EU, the correlation coefficient between GHG emissions and Gross value added of agriculture is 0.97. This value shows the strong dependency between the two variables.

The analysis of emissions in absolute expression is not always suitable for agriculture because their volume depends on the production level, its nature and the used technologies. Therefore, the analysis of the correlation between pollutant emissions and the agricultural production can use the indicator "emissions' intensity". It is calculated by relating agricultural GHG emissions to the agricultural product unit and was used in previous studies to analyze the efficiency of the agricultural production and to identify strategies to reduce emissions (Schulte, 2011). In the present study, the emissions' intensity is computed by relating GHG to gross value added by agriculture (table 2).

Table no. 2.

Evolution of agricultural GHG emissions intensity, 1999-2010

Countries	GHG from agriculture, millions tonnes of CO^2 eq			Gross value added of the agriculture (basic price), millions euro			Agricultural GHG emissions intensity – GHG from agriculture/gross value added of agriculture, kg of CO^2 eq/ euro		
	1999	2004	2010	1999	2004	2010	1999	2004	2010
Bulgaria	7.01	6.84	6.40	2051.9	1958.4	1634.3	0.34	0.35	0.39
Czech R.	9.05	8.50	7.77	2092.6	2449.9	2288.0	0.43	0.35	0.34
Estonia	1.28	1.27	1.34	313.1	361.0	411.3	0.41	0.35	0.33
Cyprus	0.74	0.77	0.66	384.1	353.9	280.0	0.20	0.22	0.24
Latvia	1.94	2.08	2.32	334.8	418.3	501.1	0.58	0.50	0.46
Lithuania	4.17	4.37	4.45	756.4	891.0	938.9	0.55	0.49	0.47
Hungary	9.39	9.39	8.26	2120.9	3316.6	2581.4	0.44	0.28	0.32
Malta	0.09	0.09	0.07	87.5	107.1	104.1	0.10	0.09	0.07
Poland	36.23	33.28	34.62	8700.2	9851.6	9785.9	0.42	0.34	0.35
Romania	18.37	17.97	16.77	6670.6	8099.9	6029.2	0.28	0.22	0.28
Slovenia	2.03	1.99	1.96	668.5	687.6	633.4	0.30	0.29	0.31
Slovakia	3.42	3.22	3.06	905.9	1290.9	1575.2	0.38	0.25	0.19
EU-EIT	93.77	89.82	87.75	25086.5	29786.2	26762.8	0.37	0.30	0.33
EU27	511.85	484.42	461.56	185395.7	200511.2	185230.6	0.28	0.24	0.25

Source: Eurostat

The data for the period between 1999 and 2010 show that agricultural emissions decreased by 9.8% throughout the EU. The reduction of GHG from agriculture in the recently integrated states in the same period was 6.4%. It was manifested an oscillatory evolution by a country to another, for the majority of them, except Estonia, Latvia and Lithuania, there was a significant drop of agricultural GHG in 2004 and 2010 compared with the initial level. This evolution has reduced the emissions' intensity in most EIT countries, with the exception of Bulgaria, Cyprus and Slovenia. Across the countries that recently joined the EU, the emissions' intensity during the period is higher that those in the EU-27, which shows the low performance of agriculture in the analyzed countries. In 2010 only Cyprus, Malta and Slovakia are below the average level of emissions' intensity, and the other countries exceed the value of the indicator.

The agricultural GHG emissions model

The impact of agricultural activities over the variation of air emissions in the 12 countries that recently joined the European Union can be tested by using the econometric regression modelling and appropriate software. In the paper we performed a regression analysis of the dynamics of the EU-EIT countries for the agricultural industry air emissions and value added over the period from 1996 until 2010.

The dependent phenomenon is characterized by the indicator agricultural greenhouse gas emissions expressed in millions of tonnes of CO^2 equivalent (GHG), which includes various greenhouse gases by their warming potential. The size of the agricultural activity responsible for GHG emissions is specified by the indicator gross value added, expressed in millions of euro basic price (GVA).

The examined countries have their own characteristics regarding GVA of the agricultural industry and GHG emissions from agriculture (table 3).

Table no.3.

Descriptive statistics of variables: agricultural GHG and GVA of 12 countries in the EU, 1996-2010

Variables	GHG emissions from agriculture, millions tonnes of CO^2 eq				GVA of the agriculture (basic price), millions euro			
	Mean	**Max**	**Min**	**St. Dev**	**Mean**	**Max**	**Min**	**St. Dev**
Bulgaria	6.64	7.92	6.23	0.518	1772.8	2051.9	1291.6	207.642
Czech Republic	8.55	9.54	7.77	0.524	2213.8	2719.6	1872.1	201.801
Estonia	1.33	1.55	1.19	0.102	347.2	411.3	238.4	42.860
Cyprus	0.73	0.84	0.65	0.054	336.3	390.7	276.0	38.702
Latvia	2.15	2.32	1.94	0.108	413.2	501.1	334.8	53.701
Lithuania	4.38	4.76	3.91	0.206	874.8	966.4	756.4	64.125
Hungary	8.98	9.50	8.26	0.366	2541.3	3600.2	2050.3	520.708
Malta	0.09	0.10	0.07	0.006	99.8	117.0	76.7	12.358
Poland	35.17	37.68	33.28	1.293	9124.3	9936.2	8340.4	529.915
Romania	18.26	20.35	16.75	0.918	6702.8	8099.9	5446.5	652.431
Slovenia	2.04	2.17	1.96	0.062	679.9	774.5	620.2	36.883
Slovakia	3.41	4.14	3.01	0.312	1280.5	1875.9	885.9	324.528
EU-EIT	7.64	37.68	0.07	9.655	2198.9	9936.2	76.7	2732.724

Source: Data calculated

During 1996-2010, the agriculture of the 12 EU countries with economies in transition achieved an average GVA of 2198.9 millions euro and the average of GHG emissions from agriculture was 7.64 millions tonnes of CO^2 eq. A significant contribution to agricultural emission was recorded by Poland, Romania, Hungary, Czech Republic and Bulgaria, which had also achieved high value for GVA of the agricultural industry.

The regression analysis model for the impact of agricultural production over agricultural GHG uses a total of 180 pool observations, being made from time series/cross-section data. The general function is described by the equation below (Anderson et al, 2007):

$$Y_{it} = \alpha_i + \beta_i X_{it} + \varepsilon_{it} \qquad (1)$$

where: Y_{it} is the dependent variable (GHG emissions);

X_{it} - independent variable (GVA of agriculture);

α_i - intercept term;

β_i - parameters (regression coefficients);

ε_{it} - residual factors of regression;

i – cross-section data;

t – time series data.

The regression coefficients express the elasticity of agricultural GHG emissions compared to the agricultural production's value. The model is estimated with cross-section specific coefficients in order to obtain the characteristic regression coefficients for each country and the overall for the newest EU members. The control for correlation of the disturbances between the cross-sections was made with SUR option. The results are presented in table 4.

The acceptance of the regression model is based on the evaluation of its statistical quality. In order to achieve this, the t-Student statistic is used to check the parameters' significance for each independent variable, the LLC (Levin, Lin&Chu, 2002) is used for the residuals' analysis and for testing the appropriateness of the regression for the whole group of examined countries.

The p-values probabilities of the t-statistic are smaller than the significance level of 0.01, which indicates that for each country, the achieved regression parameters are significant.

By applying the LLC test, we check the null hypothesis according to which there is a unit root in regression residuals (they are non-stationary), the alternative being that they are stationary. Examining stationarity is equivalent with testing the existence of unit roots in data series and the impact of potential shocks over the future manifestation of the studied phenomena. In case of stationary series, the effects produced by shocks on the evolution of data series may disappear gradually and the manifestation of the phenomena might not be affected by them (Wang, 2009).

LLC *t* statistic is -3.9 (p-value 0.0000), a level that is considered significant because the probability of occurrence for the statistic is lower that the significance threshold of 0.05. Therefore, the null hypothesis is rejected and it is concluded that the residuals are stationary. On this basis it's stated that the two studied phenomena are co-integrated and are evolving in common cycles. At the same time, the high value of the determining ratio adjusted R^2 suggests that the regression analysis is significant and the model is valid.

Table 4. Agricultural GHG emissions model according to the Gross value added

Countries	Regression coefficients	t-statistic	P-value
Bulgaria	3.702600	27.47513	0.0000
Czech Republic	3.821990	27.34274	0.0000
Estonia	3.768841	20.97075	0.0000
Cyprus	2.168263	61.81493	0.0000
Latvia	5.154011	33.90775	0.0000
Lithuania	4.993917	69.22212	0.0000
Hungary	3.386334	16.94562	0.0000
Malta	0.911896	26.33296	0.0000
Poland	3.838672	45.51160	0.0000
Romania	2.707159	47.03991	0.0000
Slovenia	2.994600	71.07293	0.0000
Slovakia	2.462396	11.28224	0.0000
EU-EIT	3.424986	55.59478	0.0000
Adjusted R^2	0,98		

Source: Data calculated with Eviews 7.1

The obtained results show that during 1996-2010 there was a strong, direct and positive relationship between the dependent phenomenon and its influence factor. The significance of the connection proves the major impact of agricultural activities on agricultural GHG emissions.

A ranking made in accordance to efficiency of emissions shows that out of the recently integrated countries, the higher emissions' intensity and the lowest efficiency are recorded in Latvia (5.15 kg CO^2/euro). It is followed by Lithuania, Poland, Czech Republic Estonia, Bulgaria, Hungary, Slovenia, Romania, Slovakia, Cyprus and Malta.

For Romania, it can be estimated that between 1996 and 2010, agricultural activities resulted in 2.7 kg CO^2 per obtained euro. This level of emissions' intensity may be considered acceptable, being below the average of 3.43 kg CO^2/euro recorded by the 12 examined countries and about 2 times lower than the maximum value of the indicator recorded in Latvia.

The proposed model can be used to simulate the GHG emissions by taking into account different development scenarios of the agricultural production.

Effective management solutions of the impact of agriculture on the environment don't require fewer agricultural activities, but the opposite, namely their development according to the principles of sustainable development. The ways in which agriculture can contribute to reducing emissions and implicitly to sustainable development are summarized in a few directions within The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007a). These directions refer to crop rotations and farming system design; nutrient and manure management; livestock management, pasture and fodder supply improvement; fertile soil maintenance and restoration of degraded land.

Reducing the agriculture's impact on GHG is related to the introduction and use of elements of sustainable agriculture, such as: increasing productivity and efficiency of the agricultural production; adopting agricultural technologies that reduce foreign consumptions (crop rotation); converting conventional production systems to become organic and low-external-input agricultural practices; improving the management of natural resources; improving soil quality by recycling nitrogen, meaning using organic and green manure and fixing plants; extending integrated agricultural systems; implementing production systems that support the environment and, at the same time, are more productive and create added value, stimulating investments that will facilitate the adaptation of production technologies to the effects of climate change (Niggli et al., 2009).

Conclusions

The analysis of the relationship between agricultural GHG and the value created in the agricultural sector has highlighted the powerful impact of agricultural activities on the increase of air pollution.

To characterize the specific relationship between agricultural GHG emissions and the GVA of the countries that recently joined the EU we used series of statistical data of the Eurostat database for the period 1996-2010. The using of the dynamic analysis of data allowed to study the agricultural production's impact on GHG emissions on short term, but in order to find the manifestation law on long term the econometric modelling method was used.

In the European Union in 2010, agriculture is responsible for 9.8% of greenhouse gas emissions, the largest polluters (in absolute size) among the newest EU members are Poland, Romania, Hungary, Czech Republic, Bulgaria and Lithuania. However, European agriculture fits within the efforts to reduce GHG emissions, which have decreased during the analyzed period.

Studying of the indicator agricultural GHG emissions/gross value added of agriculture shows that in some of the recently integrated states agriculture had lower the efficiency (Bulgaria, Cyprus and Slovenia) but the others had a better evolution.

The regression analysis for 1996-2010 allowed to identify the functional relationship between GHG emissions and gross value added by agriculture, and to compute the regression coefficients that express the dependent relationship between the variables analyzed for the EU new member states.

The aspects resulted from the analysis show the strong, direct and positive relationship between agricultural activities and GHG emissions. This is why significant importance should be attached to adopting measures that will ensure the reduction of negative effects on the environment, integrated into sustainable economic development. In this respect, agriculture is an option, an investment opportunity and a necessary tool to increase the economy's sustainability.

The further research will take into consideration the entire impact of agricultural industry on the air emissions. It will analyze the relationship between the global production of agriculture which includes also the production expenses besides the added value, and greenhouse emissions, in order to identify the actual intensity of the phenomenon.

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