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DECOUPLING ANALYSIS OF BULGARIA'S AGRICULTURE

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ABSTRACT

The article examines the possibility for applying a decoupling analysis to Bulgaria's agriculture by analysing the relationships between its driving force and environmental pressures. The analysis methodology is adjusted for the purposes of the study. The empirical study covers the period from 1990 to 2012, during which the Republic of Bulgaria, as a party to the UN Framework Convention on Climate Change (UNFCCC), had to implement certain measures to reduce its greenhouse gas emissions. The results of the analysis show that during that period absolute decoupling prevailed in Bulgaria's agricultural sector.

Keywords: Greenhouse gas emissions, Agriculture, Driving force, Environmental pressures, Decoupling analysis, Bulgaria.

JEL Classification: Q 10.

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Contribution/ Originality

The paper's primary contribution in the existing literature is that it adapts the decoupling analysis methodology to the sector of agriculture in Bulgaria.

1. INTRODUCTION

The theoretical and practical economic challenges posed by climatic changes are pertinent and comprehensive. One of the aspects related to possibilities for reducing the emissions of greenhouse gases (GHG) is to measure the relationship between the environmental pressure variable and the driver variable. In economic literature, this type of analysis is known as decoupling analysis.

The main objective of this article is to summarize and propose a decoupling analysis methodology for Bulgaria's agriculture. In order to achieve it, the author has defined the following tasks:

1. To determine the relationship between the driver and the environmental pressure in agriculture;
2. To review the existing decoupling analysis methodologies;
3. To propose a customized analysis methodology;
4. To perform a decoupling analysis with actual data for Bulgaria's agriculture.

2. METHODOLOGICAL GROUNDS OF DECOUPLING ANALYSIS

The Ministry of Environment and Water (MEW) and the Executive Environment Agency (EEA), in collaboration with the Ministry of Economy, Energy and Tourism (MEET), the Ministry of Agriculture and Food (MAF) and the National Statistical Institute (NSI) develop an annual National report on the status and protection of the environment in the Republic of Bulgaria. The results from the analyses and summaries of the information are published in a specialized publication on *environmental indicators* (IAOS, 2008). According to this publication an

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indicator is calculated from selected data from certain statistical aggregates that are most important in defining the significance and the specific representation of that indicator. In terms of GHG emissions, they are indicative for Bulgaria's contribution to climate change effects. Internationally, the main indicator for the GHG emissions is the *GHG emissions per capita* indicator.

According to some authors (Pavlov, 2014) modern society cannot afford to use our planet's resources as it used to. This problem may be solved by applying the sustainable development concept, which includes three main components: economic, social and environmental. The same author performed a thorough analysis of the indicators that comprise each component and the results imply that one of the drivers of the economic component is the GDP per capita indicator while the environmental component is driven by the GHG emissions indicator.

Other researchers (Nikolova, 2013) believe that on a sectoral level we can use resultant indicators (such as GDP generated by agriculture and GDP per agricultural worker) to characterize the sustainable development in this sector. The recommended use of such indicators proves the feasibility of agricultural GHG emissions to agricultural GDP indicator.

The main environmental indicators used by the MEW are based on methodologies, implemented in the assessment reports of the European Environment Agency, the Committee of Environmental Policy of the UN Economic Commission for Europe, EUROSTAT, etc.

Indicators are tools that provide quantitative and qualitative information about five interrelated elements:

- *Driving Force* – the sources of change of the environment status;
- *Pressure* – factors with impact on the environment;
- *State* – assessment of the current status of the environment;
- *Impact* – assessment of the impact of environmental pollution on human health and the environment;
- *Response* – assessment of the effectiveness of environmental measures and policies.

Chart 1 shows this interrelation in the sector of agriculture.

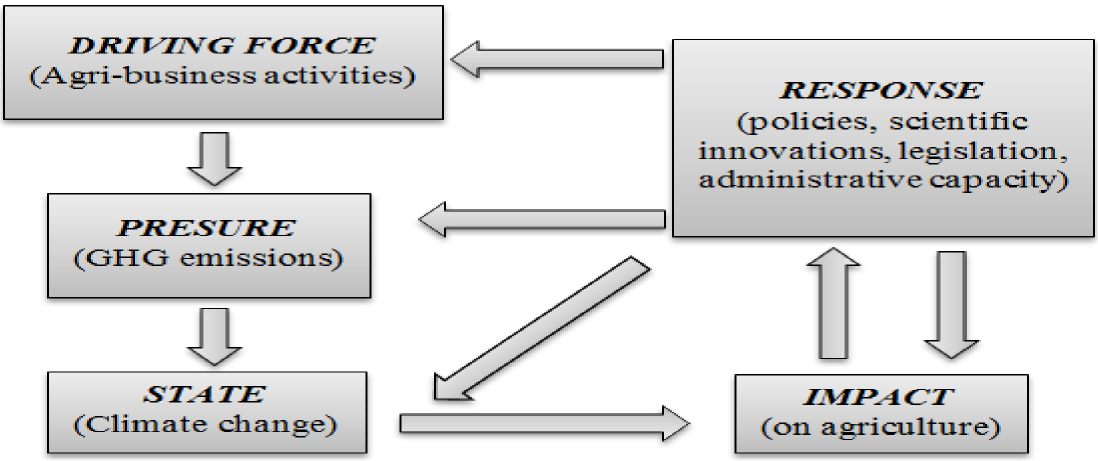

Chart-1. Interrelated elements comprising the environmental indicators for the agricultural sector
Source: ExEA's Environmental indicators chart 2008 modified by the author

The above chart shows that agri-business activities are the driving force that exerts pressure (through GHG emissions) on climate. In turn, climatic change has an impact on agriculture. Simultaneously certain measures are being implemented with regard to each of the other four elements. The focus of our research is on the relationship between the driving force and the pressure.

Decoupling analysis can be defined as a modern approach to studying the relationship between the driving force and the environmental pressure. According to Zhang (2016) this method was applied to environmental problems for the first time in 2000 and two years later was implemented by the Organisation for Economic Co-operation and Development (OECD). Their report on "Indicators to Measure Decoupling of Environmental Pressure from

Economic Growth" (OECD, 2002) states that decoupling occurs when the growth rate of an environmental pressure is less than that of its economic driving force. In our case we assume that the driving force is the Gross Domestic Product (GDP). In other words, the economic growth rate is greater than the growth rate of environmental pollution (GHG emissions in the atmosphere) over a given period.

Decoupling can be either absolute or relative. *Absolute decoupling* is said to occur when the environmentally relevant variable is stable or decreasing while the economic driving force is growing. *Relative decoupling* occurs when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of the economic variable.

A decoupling indicator is a ratio between two variables. It has an environmental pressure variable for numerator and an economic variable as denominator. Sometimes, the denominator or driving force may be population growth or some other variable.

Decoupling indicators measure changes over time. They may be interpreted correctly and should be considered significant when there is an absolute decoupling. The choice of the period to analyse is also important when decoupling indicators are used to compare environmental performance among countries. Moreover, decoupling indicators, like all other types of indicators, shed light on particular aspects of the economic events but leave out other aspects.

The information regarding the decoupling of the environmental pressure from the driving force is visualised using the time series of both variables in a graph. Thus we can determine whether the driving force increases or decreases, whether the decoupling is absolute or relative, when it starts and whether it is still doing on, etc. This approach is used in all OECD countries. There may be statistical data gaps regarding the decoupling in certain years, which are presented as straight lines.

The decoupling indicator can be expressed as (1):

$$DR = \frac{\left(\frac{EP}{DF}\right) end\ of\ period}{\left(\frac{EP}{DF}\right) start\ of\ period}, \qquad (1)$$

where:

DR – decoupling ratio;

EP – environmental pressure;

DF – driving force.

If DR < 1 over the period, then there is decoupling, but we still cannot determine whether it is absolute or relative. To do this we have to calculate the *Decoupling Factor* (DF) as (2):

$$DF = 1 - DR. \qquad (2)$$

When DF ≤ 0, there is no decoupling and its maximum value is 1 when the environmental pressure variable is 0. Note that the decoupling factor changes are not linear although the changes of the environmental pressure and driving force variables are linear.

The OECD report also defines the *criteria* for conceptual soundness of the decoupling indicators (OECD, 2002) putting an emphasis on the fact that in reality a given indicator may not always meet all criteria. Therefore, we may summarize that environmental indicators should correspond to the current policy, be useful for the consumers, have good explanatory qualities, be suitable for incorporation in various models and be reliably measurable.

The indicators recommended by the OECD can be used in the development of the methodology in this research because they are implemented in all EU member-states that are members of the OECD as well. In some scientific research the OECD methodology is implemented directly, but on different levels while in others it has been supplemented and developed further. Here is a review of the main concepts that are subject to development.

One of the aspects of implementation of the OECD approach is on a small-country level. Some authors (Conrad, 2014) analysed the decoupling of economic growth and environmental degradation in terms of decoupling ratio (1) and factor (2) without modifying the OECD approach. Their analysis covers four sectors: 1) energy intensity, climate change and air quality; 2) water; 3) waste, and 4) land. The results from their analysis indicate a moderate decoupling between economic growth and some indicators and lesser decoupling between population increase and certain environmental pressure indicators. Their general conclusion is that an analysis of environment-economy decoupling based on a single indicator (e.g. carbon dioxide emissions) is incomplete and may be misleading. Although we need a complex approach, such an analysis on a small scale level (small countries such as Malta or single cities) would be useful.

Other researches have adopted an approach that differs from the one used by the OECD and that was introduced in an article by Tapio (2005). In his research he analyses the decoupling between economic growth and environmental pollution factors, in particular transport volume. Tapio measures decoupling of transport volume growth from economic growth in terms of GDP elasticity of transport and transport CO_2 emissions to derive the "GDP elasticity of transport CO_2", i.e. he combines the concepts of "decoupling indicator" and *decoupling elasticity* (e_d). In our research the elasticity is calculated as (3):

$$e_d = \frac{\%\Delta EP}{\%\Delta DF}, \qquad (3)$$

i.e. as the ratio of the percentage change of the environmental pressure variable and the percentage change of the driving force variable.

As Tapio noted, a number of different concepts have been used to express the different aspects of decoupling. For example, decoupling measured by GDP elasticity of transport (i.e. the ratio of the change of transport volume (passengers/km or freight/km) to the change of GDP is referred to as immaterialisation (qualitative growth) and structural change. Decoupling measured by the ratio of the percentage change of CO_2 emissions to the percentage change of transport volume (referred to as transport elasticity of CO_2 emissions) has been called also dematerialisation, eco-efficiency and simply industrial development. Decoupling measured by the GDP elasticity of transport CO_2 emissions has been termed as decarbonisation or de-linking. Sometimes "de-linking" is used as a wider synonym for "decoupling". For the purposes of our research the two terms are used as absolute synonyms.

Tapio redefined the term "decoupling" stating that on one side of the discourse, it is claimed that in the early phases of economic development, growth is achieved with increasing environmental problems, that is, pollution and exploitation of the resources. As the development continues, the economy will become less harmful for the environment due to investments in technological and economic efficiency.

When using economic output per capita as the x-axis and environmental harm as the y-axis, an inverted U-curve will appear. This means that at a certain point of economic development the growth of production output will decouple from the growth of environmental pollution. This is often called the environmental Kuznets curve hypothesis (Kuznets, 1955). According to Tapio (2005) the Kuznets curve hypothesis was used for the first time in the environmental analysis of Todaro in 1994. With this article the author does not aim to determine who was the originator of the idea to use decoupling analysis in the field of environmental issues but to prove that this is an innovative and useful approach. Some researchers (Stern, 2016) have conducted a number of empirical studies in order to verify or reject the Kuznets curve hypothesis in terms of economic growth and environmental pollution, which proves that this method is currently applicable.

Key stages of decoupling analysis are the definition of elasticity thresholds and results interpretation. Tapio (2005) distinguishes eight logical possibilities for the relationship between the growth rate of GDP and the indicator of traffic volume grouped into three categories – coupled, decoupled or negatively decoupled. He performed an analysis of the EU15 countries in the period 1970 – 2001 putting an emphasis on Finland. The aggregated data show a change from expansive negative decoupling to expansive coupling for passenger transport and from weak decoupling to expansive negative decoupling for freight transport. Weak decoupling of the freight transport and passenger transport from the CO_2 emissions was calculated for the 90s in the UK, Sweden and Finland.

Later on Tapio's categorization was used by other authors as well. It was adapted to agriculture by Zhang in 2016. According to him the decoupling analysis should be based on the following equation:

$$e_d = \frac{\Delta E_A / E_{A_n}}{\Delta GDP_A / GDP_{A_n}} = \frac{\%\Delta EP}{\%\Delta DF}, \qquad (4)$$

where:

E_{A_n} – the volume of GHG emissions from agriculture in year *n*;

ΔE_A – the change of the volume of GHG emissions from agriculture in year *n* from the previous year;

GDP_{A_n} – GDP from agriculture in year *n*;

ΔGDP_A – the change of GDP from agriculture in year *n*, from the previous year.

If we compare equations 4 and 3, we can see that in measuring the decoupling between the environmental pressure and driving force variables (regardless of the sector) the method used to calculate the change of variable values is very important. In this case they are used incrementally, i.e. as a change for each year from the previous one ($\Delta E_A = E_{A_n} - E_{A_{n-1}}$).

To calculate the annual percentage changes we should substitute E_{A_n} with $E_{A_{n-1}}$ and GDP_{A_n} with $GDP_{A_{n-1}}$. Thus the equation becomes:

$$e_d = \frac{\Delta E_A / E_{A_{n-1}}}{\Delta GDP_A / GDP_{A_{n-1}}} = \frac{\%\Delta EP}{\%\Delta DF}. \qquad (4\text{ a})$$

Alternatively, we can use an aggregate base when we want to calculate the values for a certain period. For example, in the Kyoto Protocol the EU has committed to the target of reducing total greenhouse gas emissions by 5% until 2008–2012 from the values of 1990. In this case we can measure the volume of emissions based on their 1990 value rather than the incremental annual change. Then $\Delta E_A = E_{A_n} - E_{A_0}$ and decoupling elasticity will be calculated using the following equation:

$$e_d = \frac{E_{A_n} - E_{A_0} / E_{A_0}}{GDP_{A_n} - GDP_{A_0} / GDP_{A_0}} \qquad (5).$$

The changes of decoupling elasticity (e_d) are presented in Table 1 below.

Table-1. Decoupling status categories

Categories of decoupling status		Environmental pressure change (ΔEP)	Driving force change (ΔDF)	Decoupling elasticity (e_d)
Decoupling	Weak	$\Delta EP > 0$	$\Delta DF > 0$	$0 \le e_d \le 0{,}8$
	Strong	$\Delta EP < 0$	$\Delta DF > 0$	$e_d < 0$
	Recessive	$\Delta EP < 0$	$\Delta DF < 0$	$e_d > 1{,}2$
Negative decoupling	Expansive	$\Delta EP > 0$	$\Delta DF > 0$	$e_d > 1{,}2$
	Strong	$\Delta EP > 0$	$\Delta DF < 0$	$e_d < 0$
	Weak	$\Delta EP < 0$	$\Delta DF < 0$	$0 \le e_d \le 0{,}8$
Coupling	Expansive	$\Delta EP > 0$	$\Delta DF > 0$	$0{,}8 \le e_d \le 1{,}2$
	Recessive	$\Delta EP < 0$	$\Delta DF < 0$	$0{,}8 \le e_d \le 1{,}2$

Source: Adapted from Zhang (2016)

In addition to the method for calculating decoupling elasticity, Zhang proposes a model for verification of the Kuznets Hypothesis – a second order regression model, in which the emission from agriculture are used as an environmental indicator and the GDP from agriculture is an indicator of the economic growth in the sector. The model is based on the following equation:

$$E_{A_i} = \beta_0 + \beta_1 E_A GDP_{A_i} + \beta_2 \left(E_A GDP_{A_i}\right)^2 + e_i \,, \qquad (6)$$

where i is the corresponding year. If β_1=0 and β_2=0, then the economic growth in agriculture is not coupled with the generation of GHG emissions and the two variables are strongly decoupled, i.e. there is a strong decoupling. If $\beta_1 \neq$0 and β_2=0, we assume that there is a linear coupling between the emission from agriculture and the economic growth in the sector, i.e. they are strongly coupled. Finally, when $\beta_1 \neq$0 and $\beta_2 \neq$0, there is an inverse-U shape relationship between the two variables, i.e. there is a weak decoupling.

Zhang analyses the decoupling across nine suburbs in Shanghai for a period of 18 years. The regression results are statistically significant and suggest that agro-emission does have inverse-U shape relationship with agricultural development in Shanghai, i.e. agro-emission is weakly decoupled from agricultural development.

Another wide-scale research (Ru *et al.*, 2012) based on Tapio model conducted a quantitative analysis of the relationship between economic growth and CO_2 emissions in six developed countries (the USA, Canada, Japan, the UK, France, and Sweden) and three developing countries (China, Brazil and India). The general conclusion is that decoupling can be stable and that strong decoupling is not necessarily related to economic stagnation. The developing counties need more time to catch up with their developed counterparts in terms of decoupling of economic growth from CO_2 emissions.

The analysis of decoupling in agriculture may be combined with other approaches. In an article published in 2016 Zhen (Zhen *et al.*, 2016) uses a decoupling ratio analysis and an analysis of decoupling elasticity to determine the dynamics of production of crops with low CO_2 emissions in a Chinese province. The authors use the term "*carbon footprint*" (CF) to refer to all direct and indirect emissions throughout the whole life cycle from production to the final consumption of a given product. This indicator is important for the management of GHG emissions and the carbon footprint assessment is widely applicable to the sector of agriculture. Zhen, W. et al. used the OECD methodology to analyse decoupling.

Using the index of logarithmic distribution method for the period 1993 – 2013 the authors obtained the following results: 1) increase of agricultural output and the increase of the carbon footprint from agricultural production are not always directly related; 2) there is an overall trend of weak decoupling between carbon footprint and agricultural production; 3) decoupling stability coefficients show that there is a danger of induction of high emission levels from agricultural production; 4) the level of development of agriculture is the main factor that affects its carbon footprint and, therefore, investments in agriculture, urbanisation and technological advancements contribute to the reduction of the carbon footprint in the studied Chinese province.

Another recent study on the reduction of GHG emissions and decoupling indicators was conducted by Grand (2016). Based on an extensive review of the existing literature sources in this field (including Tapio, Conrad, Zhang, the OECD approach and the other sources described in this section) the author introduces the following metrics to measure decoupling:

First, *emissions' growth* (e) – the numerator of equation (4 a), using the same symbols, is described as:

$$\mathrm{e} = \frac{\mathrm{E}_{A_n} - \mathrm{E}_{A_{n-1}}}{\mathrm{E}_{A_{n-1}}} = \frac{\mathrm{E}_{A_n}}{\mathrm{E}_{A_{n-1}}} - 1\ . \qquad (7)$$

Second, similarly, for the *economic growth* (g) – the denominator of equation (4 a) is described as:

$$g = \frac{GDP_{A_n} - GDP_{A_{n-1}}}{GDP_{A_{n-1}}} = \frac{GDP_{A_n}}{GDP_{A_{n-1}}} - 1. \qquad (8)$$

Third, the growth rate of *emissions' intensity* (t):

$$t = \frac{\left(\frac{\mathrm{E}_{A_n}}{GDP_{A_n}}\right) - \left(\frac{\mathrm{E}_{A_{n-1}}}{GDP_{A_{n-1}}}\right)}{\left(\frac{\mathrm{E}_{A_{n-1}}}{GDP_{A_{n-1}}}\right)} = \frac{\left(\frac{\mathrm{E}_{A_n}}{GDP_{A_n}}\right)}{\left(\frac{\mathrm{E}_{A_{n-1}}}{GDP_{A_{n-1}}}\right)} - 1. \qquad (9)$$

If we substitute the general variables in equations 1 and 2 with the specific variables used above (i.e. the environmental pressure variable (EP) with the variable of the GHG emissions from agriculture E_A and the driving force variable (DF) with the variable of the GDP from agriculture (GDP_A)), we shall get:

$$DF = 1 - \frac{\left(\frac{E_{A_n}}{GDP_{A_n}}\right)}{\left(\frac{E_{A_{n-1}}}{GDP_{A_{n-1}}}\right)}. \qquad (10)$$

As Grand noted, when equations 9 and 10 are compared it is obvious that:

$$DF = -t, \qquad (11)$$

or, for the decoupling factor (DF) grounded on the rate of growth of emissions intensity and economic growth, decoupling is synonymous of increasing emissions' intensity ($-t$). Hence the degrees of decoupling described in Table 2 below.

Table-2. Degrees of decoupling based on decoupling factor

Indicator value (DF)	Emissions' rate of change (t)	Decoupling degree
$DF < 0$	$t > 0$	No decoupling
$DF = 0$	$t = 0$	No decoupling
$DF > 0$	$t < 0$	Decoupling

Source: Adapted from Grand, 2016

On the third row in Table 2 there is decoupling because the factor has a positive value and emissions' intensity is decreasing. Moreover, DF=1 when $\frac{E_{A_n}}{GDP_{A_n}} = 0$.

This indicator is easy to compute and this is why it is widely used in empirical research. According to Grand, however, it has certain limitations because decoupling is only associated to a reduction in emissions' intensity, but it can coexist with emissions that are not decreasing when the economy is in expansion and with emissions decreasing but with economic activity stagnating or falling.

To solve that weakness Grand suggests the use of the decoupling elasticity recommended by Tapio and expressed with equation 4a above.

Decoupling elasticity (e_d) in itself cannot determine whether decoupling is absolute or relative. This is why, similarly to OECD's approach (equations 1 and 2), we can introduce a third indicator (e_t), expressed as:

$$e_t = 1 - e_d. \qquad (12)$$

The degrees of decoupling for the three indicators (DF, e_d, e_t) used in our analysis are shown in Table 3 below. The indicators are calculated using the three metrics (e, g, t), which determine the relationships among them.

The review of the literature sources which deal with the analysis of the decoupling of the environmental pressure variable from the driving force leads to the following conclusions:

- Decoupling analysis is a modern approach which is still widely used;
- This analysis provides sound results on various levels – for administrative regions, small and large states, OECD and EU member-states and other states around the world. This means that the decoupling analysis is a universal tool for comparison of different economies;
- The analysis can be conducted for separate economic sectors such as agriculture;
- Decoupling analysis may be combined with other methods to provide additional and complex results.

Table-3. Degrees of decoupling with the three indicators

Case	e	g	t	$DF = -t$	$e_d = \frac{e}{g} = \frac{g + t + gt}{g}$	$e_t = \frac{-t}{\frac{g}{1+g}}$
1	> 0	> 0	> 0	< 0 Non decoupling	> 1 Expansive negative decoupling	< 0 Non decoupling
2	$e = g > 0$	> 0	$= 0$	$= 0$ Non decoupling	$= 1$ Expansive coupling	$= 0$ Non decoupling

3	> 0	> 0	< 0	> 0 Decoupling	$> 0, t > -g/(1+g) < 1$ Weak decoupling	$> 0 < 1$ Relative decoupling
4	$= 0$	> 0	< 0	> 0 Decoupling	$= 0, t = -g/(1+g)$ Not defined	$= 1$ Absolute decoupling
5	< 0	> 0	< 0	> 0 Decoupling	$< 0, t < -g/(1+g)$ Strong decoupling	> 1 Absolute decoupling
6	< 0	< 0	> 0	< 0 Non decoupling	$> 0, t < -g/(1+g) < 1$ Weak negative decoupling	$> 0 < 1$ Relative decoupling
7	$= 0$	< 0	> 0	< 0 Non decoupling	$= 0, t = -g/(1+g)$ Not defined	$= 1$ Absolute decoupling
8	> 0	< 0	> 0	< 0 Non decoupling	$< 0, t > -g/(1+g)$ Strong negative decoupling	> 1 Absolute decoupling
9	$e = g < 0$	> 0	$= 0$	$= 0$ Non decoupling	$= 1$ Recessive coupling	$= 0$ Non decoupling
10	< 0	< 0	< 0	> 0 Decoupling	> 1 Recessive decoupling	< 0 Non decoupling

Source: Adapted from Grand (2016)

The official statistical sources of agricultural data – NSI and MAW – do not provide information about the GDP from agriculture but only about the Gross Value Added (GVA).

According to this methodology (NSI, 2016) GDP is calculated in the form of work-in-progress as follows:

+ GVA: total for the economy (at basic prices)

+ Corrections

= GDP at market prices.

The official statistics provides the GVA values for the separate economic sectors (agriculture, industry and services) but the corrections are given as a total value for the whole economy and therefore we cannot calculate the GDP for each sector. The "Corrections" item includes all net taxes on production. The value of all taxes on production is adjusted with the subsidies on production including the non-deducible VAT and the export duties.

Section "Agriculture" of the Statistical Yearbook states that the Economic accounts for Agriculture are satellite accounts in the framework of the National Accounts. They provide complementary information and concepts adapted to the particular nature of the sector. Output of the industry represents all of the services and products produced by all units with agricultural activity. Data refer to the final production and goods and services produced and consumed by the same unit for the same period are excluded. The main purpose of the elaboration of the economic accounts is the calculation of the entrepreneurial income for the agricultural industry. It is calculated as follows:

Crop output

+ Livestock output

+ Agricultural services

+ Inseparable non-agricultural activities

= **Output of the agricultural sector**

– Intermediate consumption

= **Gross Value added**

– Fixed capital consumption

= Net value added

– Compensation of employees

– Other taxes on production

+ Other subsidies on production

= **Net operating surplus/Mixed income**

– Rents paid

– Interest paid

+ Interest received

= **Net entrepreneurial income**.

Therefore, the Net Entrepreneurial Income (NEI) in agriculture is calculated by adjusting the GDP from agriculture with the above corrections. This approach is equivalent to the approach adopted for calculating the GDP for the whole economy. Therefore, the "GDP from agriculture" variable can be substituted in equations 4, 4a, 5, 6, 8, 9 and 10 with the variable **GVA from agriculture**.

3. DATA ANALYSIS AND RESULTS INTERPRETATION

The first step of the analysis of decoupling between GHG emissions (pressure) and GVA (driving force) in Bulgaria's agriculture is to draw a graph of the dynamics of these two variables. The dynamics for the period 1990 – 2012 is shown in Figure 1. The GHG emissions are in gigagrams equivalent of carbon dioxide (CO2eq) and GVA is in BGN million. Data was generated from the FAOSTAT database.

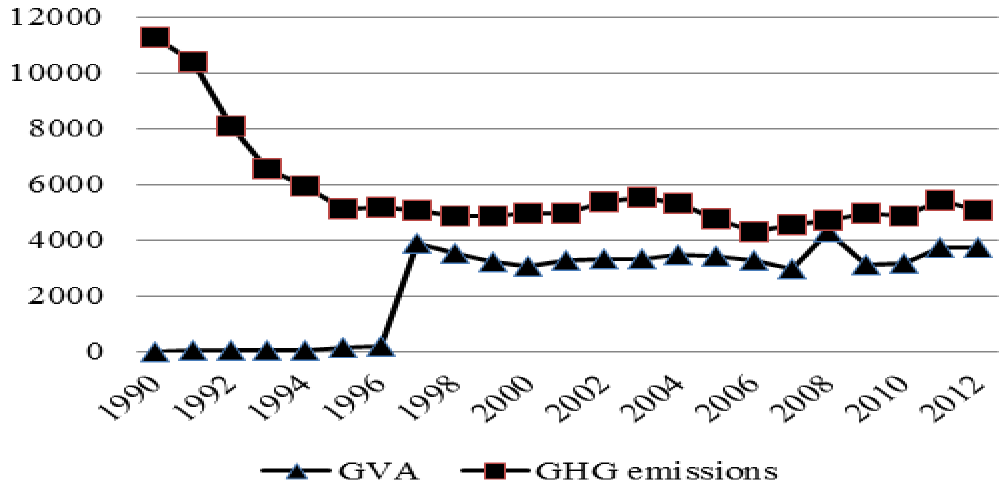

Figure-1. GHG emissions and GVA for the period 1990 – 2012.
Source: author's own elaboration

The two curves in Figure 1 have obviously different dynamics. GHG emissions decrease constantly from the beginning of the period till 1995, after which observed relatively smooth change. GVA remains stable during the first six years, rapidly increases in 1997 and fluctuates around that level for the remaining of the period.

The next step is to calculate the three decoupling indicators. The calculated values are shown in Table 4.

Table-4. Decoupling indicators of Bulgaria's agriculture

Years	Emission growth (e)	GVA growth (g)	Emissions' intensity (t)	Decoupling factor (DF)	Decoupling elasticity (e_d)	Decoupling rate (e_r)	Case
1990/1991	-0,08	1,51	-0,63	0,63	-0,05	1,05	5
1991/1992	-0,22	0,12	-0,30	0,30	-1,90	2,90	5
1992/1993	-0,19	0,27	-0,37	0,37	-0,70	1,70	5
1993/1994	-0,09	1,03	-0,55	0,55	-0,09	1,09	5
1994/1995	-0,14	0,85	-0,54	0,54	-0,17	1,17	5
1995/1996	0,01	0,78	-0,43	0,43	0,02	0,98	3
1996/1997	-0,02	17,62	-0,95	0,95	0,00	1,00	4
1997/1998	-0,04	-0,09	0,05	-0,05	0,48	0,52	6
1998/1999	0,00	-0,09	0,09	-0,09	0,00	1,00	7
1999/2000	0,02	-0,05	0,08	-0,08	-0,48	1,48	8
2000/2001	0,01	0,06	-0,05	0,05	0,11	0,89	3
2001/2002	0,07	0,01	0,07	-0,07	10,63	-9,63	1
2002/2003	0,04	0,00	0,03	-0,03	11,18	-10,18	1
2003/2004	-0,04	0,04	-0,08	0,08	-0,94	1,94	5
2004/2005	-0,11	-0,02	-0,09	0,09	6,55	-5,55	10
2005/2006	-0,10	-0,04	-0,06	0,06	2,26	-1,26	10
2006/2007	0,06	-0,09	0,17	-0,17	-0,66	1,66	8
2007/2008	0,04	0,45	-0,28	0,28	0,08	0,92	4
2008/2009	0,05	-0,28	0,45	-0,45	-0,17	1,17	8
2009/2010	-0,02	0,02	-0,05	0,05	-0,89	1,89	5
2010/2011	0,12	0,17	-0,04	0,04	0,70	0,30	3
2011/2012	-0,07	0,01	-0,08	0,08	-7,75	8,75	5

Source: author's calculations

The emissions' intensity (t) per unit of GVA is shown in Figure 2. From 1990 to 1997 the intensity is low. It sharply increased in 1998 and fluctuated around the zero level until 2006. After a sequence of increases and decreases in the period 2006 - 2010 it remained relatively stable at the zero level for the last three years (2010 – 2012).

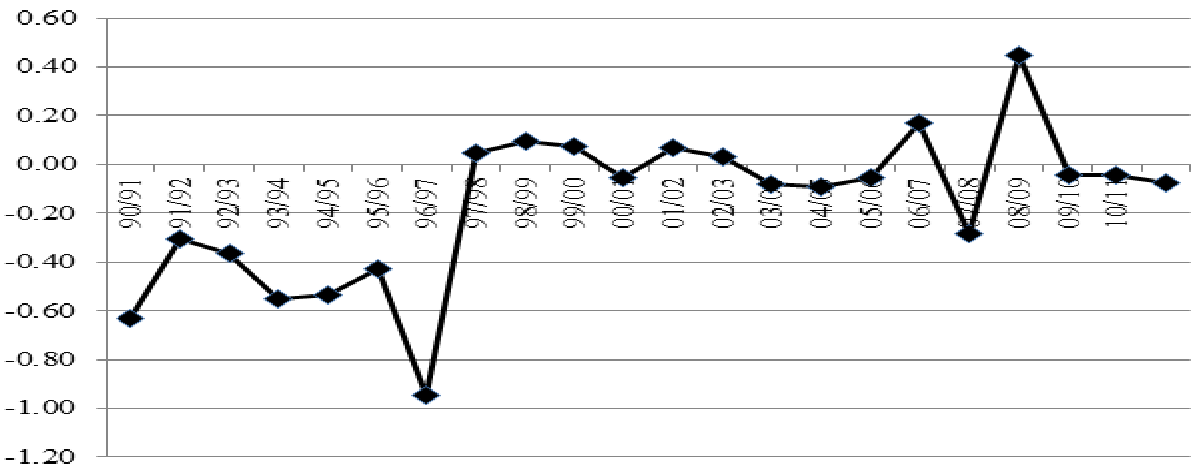

Figure-2. GHG emissions intensity

Source: author's own elaboration

When we set a coordinate system plotting the agricultural growth (g) on the horizontal axis and the emissions' intensity (t) on the vertical axis, we get the following graph in Figure 3 below.

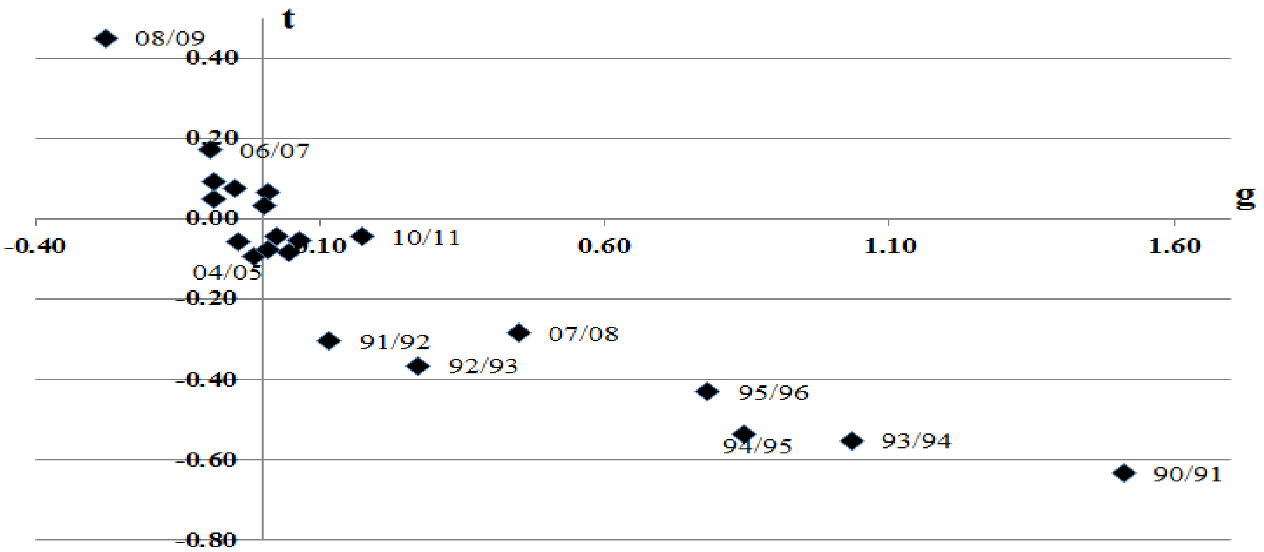

Figure-3. Degrees of Coupling/Decoupling

Source: author's own elaboration

The points represented with squares on the coordinate system show the degree of coupling/decoupling of each case (Table 3 and the last column of Table 4). Most of the points are indexed with the year of the case they represent. The visual representation of the indicators (a total of 22 for the period 1990 – 2012) shows that Case 5 is dominant (8 representations), which means that during the corresponding years (the first five years and in 2003/2004, 2009/2010 and 2011/2012) there was an absolute decoupling. Cases 4, 7 and 8 (also absolute decoupling) were calculated for 1996/1997, 1998/1999, 1999/2000 and 2006 through 2009. Relative decoupling (Case 3) was calculated for 1995/1996, 2000/2011 and 2010/2011 and for 1997/1998 (Case 6).

Non-decoupling (cases 1 and 10) was estimated for the years 2001 through 2003 and 2004 through 2006. During the first period both the emissions and the GVA increase due to economic growth and this is why there is no decoupling, or, measured in terms of e_d, there is expansive negative decoupling. Conversely, in Case 10 (during the period 2004 – 2006) both the emissions and the GVA decrease. This is why the last three years are characterized with recessive decoupling.

4. CONCLUSION

The analysis of the decoupling of the environmental pressure from the driving force is a relatively new approach in economics. The aim of our research was to adapt the existing methodology for analysing Bulgaria's agricultural sector.

The results from the analysis of the decoupling of the GHG emissions from the GVA from this sector in the period 1990 – 2012 show that in most of the years of this period there was an absolute decoupling, which means that GHG emissions' intensity is lower than the rate of economic growth in terms of GVA from agriculture. Moreover, we may conclude that the reduction of the GHG emissions from agriculture was due to other factors rather than to a negative economic growth. The analysis also shows that Bulgaria's agriculture has a substantial capacity for further reduction of its GHG emissions, which means that the efforts to mitigate the environmental problems should be directed to a greater extent to measures for adaptation and reduction of this sector's vulnerability.

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