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GIS based Model for Evaluating Effects of Agricultural EU Funds

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Abstract

The European Union (EU) is giving significant financial support to member states through Common agricultural policy (CAP). The problem is that the effects of EU funds are not presented in the way that would allow wide auditorium to understand their benefits. This is very important because it explains where the money collected from the EU citizens is spent. The goal of this paper is to present a model of visualisation by using geographic information system (GIS) as an effective tool for simple analysis of administrative EU measures, taking into consideration multiple factors at once. Results gained by using GIS show that there is only 2 of 27 EU countries that present significant positive correlation between invested funds and agricultural outputs.

Keywords: financial support; funds; EU; evaluating; agricultural; CAP

Introduction

The total EU budget for 2014-2020 amounts to 960 billion Euros in commitments (Czyzewski & Stepien, 2014). Agriculture is a relatively small sector of EU economy. It provides for less than 2 percent of EU gross domestic product (GDP) and about 5 percent of its employment (Understanding the EU Common Agricultural Policy, 2018).

The Common Agricultural Policy of the European Union was formulated in the late 1950s and launched in 1962. It constituted 'the first successful attempt to create a single policy for one economic sector, implemented in a unified manner over the territory of a number of independent states and which governed their relationships not only with each other but also with the rest of the world' (Fennell, 1997). For many years it was the only common European Community Policy (Skogstad & Verdun, 2009).

The CAP takes action by means of the following measures:

- Support of income. Direct payments enable stability of farmers' income.
- Measures for rural development. Specific needs and challenges facing rural areas are recognized in national and regional programmes.

The CAP is financed through two funds which are part of EU budget. The European Agricultural Fund (EAGF) provides direct support and funds market measures (the so-called "first pillar" of the CAP) and is worth 277.851 billion Euros for period 2014-

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2020. The second pillar of the CAP is funded through the European Agricultural Fund for Rural Development (EAFRD) and supports EU rural development policy. It is worth 84.936 billion Euros for the same budget period. The share of CAP in EU budget has decreased over past 25 years, from 73% in 1985 to 41% in 2016. This decrease has taken place despite the successive EU enlargements (European Commission, 2013). There are many discussions about effects of the CAP and its subsidies to EU member countries. Results of research done by Szabolcs at al. implied that no significant economic development occurred. The economic impacts of CAP measures were examined as ex post evaluation of the Rural Development Programme (RDP) 2007-2013 (Szabolcs et al., 2017).

The CAP is considered to be a controversial EU policy that influences millions of Europeans, from small farmers to grocery shops, from Sweden to Spain. It takes daily from the pocket of each EU citizen around 30 euro cents ($0.41) in taxes. The United Kingdom (UK) is the biggest opponent of the CAP, although analyses show that Berlin, and not the UK, stands to lose the most from the CAP policy. The UK's criticism of the EU is targeted at inefficiency, misuse, and corruption of CAP. There is no specified formula to allocate payments and the distribution process is very political. Funds are very differently distributed among EU member states. Furthermore, the absorption of delivered payments still presents difficulties for member states, particularly countries in Central and Eastern Europe, the ones that lack skilled administration staff to lead this process. Those countries have lower labour productivity in agriculture, less mechanization, and smaller size farms. This is the case, for example, with Romania, Poland, and Bulgaria (Debating Europe, 2018).

There are many investigations for particular countries, but those are not generalized for all member states. For example, data on applying CAP in Germany shows that the Pillar 2 measures brought a moderate impact in 2006, namely, an increase in agricultural income (5%) and agricultural land use (0.15%), and increase in total greenhouse gas emissions (Schroeder et al., 2014).

Janet Dwyer (2013), focusing on Pillar 2 programmes and its various achievements, writes that CAP did not cause significant transformation in agriculture or rural areas. Particular criticism was aimed at new member states (Erjavec, 2012). Studies conclude that the policy of delivering CAP support is not well structured. This mechanism should include local specificities. It should be developed with a holistic approach and with a vision of the whole territory/sector, before any aids are further allocated and paid (Dwyer, 2013).

The goals of the authors of this paper are to:

- propose spatial visualization model for more efficient and result oriented graphical assessment of the impact of CAP measures on development of agricultural sector along EU member states.

The impact was measured by observing how payments distributed to EU member states reflect on changes of values of basic agricultural facts in the EU member states.

Starting positively, the authors wanted to confirm the following three hypotheses:

H1) Use of EAFRD and EAGF funds increases agricultural outcome in EU member states (profit),

H2) Use of EAFRD and EAGF funds increases agricultural gross value added (GVA) in EU member states (effectiveness),

H3) The most developed countries are leaders in efficient use of EAFRD and EAGF funds (leadership).

Data and Methods

To test the hypotheses authors used data collection, analysis framework, Pearson correlation coefficient, and GIS visualisation methods. The first step was to collect data on financial support realized through EAFRD and EAGF funds over the period of ten years, from 2007 to 2016. As the budget of EU lasts 7 years, this period is covered by two budgets: the whole 2007-2013 budget and the beginning of 2014-2020 budget execution. In some of the years there have been parallel payments from both budgets at the same time and this fact has been taken into account. Data was taken from official reports of the European Commission (EC, 2018).

The authors wanted to identify effects that the European Union financial support had on agricultural sector of EU member states. What criteria should be used to measure them?

They decided to analyse agricultural output and gross value added. Why are these values important to measure effects of EU funds?

Eurostat (European Statistical Office) explains that the total output of the agricultural industry in the EU in 2016 was 405 billion Euros at basic prices. Total output is a measure of value of total volume that reached the market and it consists of: „output values of crops and animals, agricultural services, and the goods and services produced from inseparable non-agricultural secondary activities" (Eurostat, 2018). 59.1% of this value was paid for interme-

diate consumption, input goods and services, mostly for: seeds and plantings, fertilisers, plant protection products, food for animals, and veterinary expenses. The residual, which is called gross value added (GVA) amounts to 40.9% of the total output and was 165.7 billion Euros. The authors selected these values to analyse the impact of EU funds on agriculture results and collected data for them from the web site of the EC - the part concerning Agriculture and rural development in the EU and the member states (European Commission, 2018b). They wanted to find dependence between that data and the payments executed through EAFRD and EAGF funds to different countries and over a longer period, in this case from 2007 to 2016.

The most usual measure of association or dependence between two groups of data is Pearson's correlation, obtained by dividing the covariance (cov) of two variables by a product of their standard deviations (σ). The strength of the correlation can be interpreted (Fennell, 1997) by the absolute value of (r) as:

- 0.00-0.19 "very weak"
- 0.20-0.39 "weak"
- 0.40-0.59 "moderate"
- 0.60-0.79 "strong"
- 0.80-1.00 "very strong"

To prove the posited hypotheses H1 and H2 for each member state, authors calculated Pearson correlation coefficient (r) by using IBM (Statistical Package for Social Science) SPSS software.

Geographic information system, open source software Quantum GIS (QGIS) Desktop version 3.0, was used for spatial visualisation of the outcomes.

Results

The data on absorption of EU funds was taken from official European Commission reports for the European Parliament (European Commission, 2018). To get the total value of realized European allocations to agricultural sector, authors added up values of EAFRD and EAGF for each year and for each country. This data with the sums for each country are presented in Table 1. Because Croatia became member of EU in 2013, it is not included in this table.

After having collected all previously presented data, the authors prepared one table for each country that presents overview of EAFRD plus EAGF sums, agricultural outputs and GVA values during the period 2007 - 2016.

Correlation is calculated for 2 cases:

Between the sums of EAFRD and EAGF funds paid to EU members states for years 2007-2016, as Xi, and

a) agricultural output (production value at basic price) for years: 2007-2016, as Yi,
b) agricultural gross value added at basic prices for years: 2007-2016, as Yi,

where i = 1, 2, ..., n, indicates the number of years taken into consideration as a sample.

All calculated correlation coefficients are presented in Table 2.

Table 1. EAFRD plus EAGF payments by years and countries, in million Euros

Country/Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Belgium	870.08	918.46	953.51	754.00	727.91	713.50	697.72	628.63	704.27	667.90	7635.98
Bulgaria	0.00	759.50	354.95	571.64	548.26	622.79	933.64	995.75	1125.84	1000.85	6913.23
Czech Republic	549.09	838.24	897.58	1049.89	1216.15	1087.99	1211.08	1177.25	1131.74	1205.94	10364.92
Denmark	1083.00	1190.24	1129.26	1066.83	1004.99	1029.64	1008.52	1020.31	1004.73	995.11	10532.63
Germany	6458.66	6890.94	7305.99	6855.10	6599.97	6843.03	6622.36	6114.31	5979.63	6277.01	65947.00
Estonia	63.01	137.27	149.82	159.75	197.90	204.24	222.04	162.14	166.51	253.62	1716.31
Ireland	1771.68	1811.21	1666.07	1681.80	1641.09	1640.68	1514.97	1235.00	1613.90	1630.97	16207.38
Greece	3004.77	3091.07	2833.63	2923.26	2830.33	2755.81	2571.79	3090.15	2749.66	2888.46	28738.95
Spain	5909.83	7481.74	6834.69	6944.55	6850.01	6765.12	6973.32	6131.16	6813.52	6555.01	67258.96
France	10100.93	9949.16	10275.21	9797.24	9396.67	10724.17	9599.80	8426.93	8977.92	8393.58	95641.62
Croatia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00	259.86	341.31	697.17
Italy	5476.86	6803.06	5512.69	5592.95	5917.14	6160.83	5937.13	5720.03	5915.81	5474.70	58511.22
Cyprus	39.38	52.87	54.96	60.21	63.96	62.86	73.03	79.90	81.25	74.64	643.06
Latvia	55.00	400.84	214.76	257.37	286.85	326.23	332.03	206.79	242.85	362.41	2685.12
Lithuania	290.04	422.74	482.29	509.86	580.72	515.27	609.93	616.38	522.79	716.17	5266.17
Luxemburg	51.42	48.96	48.41	51.95	48.29	45.36	44.09	34.29	48.22	45.67	466.67
Hungary	740.98	1097.03	1469.18	1420.49	1597.69	1506.38	1763.23	1887.35	1784.71	1663.92	14930.96
Malta	2.00	26.56	6.96	21.38	13.37	12.94	15.68	17.41	16.54	12.09	144.93
Netherlands	1162.29	1093.24	1229.37	1100.78	983.78	1049.29	1004.49	963.02	934.35	892.11	10412.71
Austria	1100.29	1340.21	1325.75	1338.71	1304.51	1282.93	1256.93	965.87	1148.74	1357.00	12420.94
Poland	2135.10	3386.23	3081.03	3506.34	4601.10	4522.04	5004.97	4915.77	5003.94	4709.46	40865.99
Portugal	926.25	1324.73	968.36	1220.93	1264.21	1453.28	1425.45	1419.12	1060.33	1508.35	12571.02
Romania	7.00	1620.69	1164.23	1434.98	1916.92	1903.92	2397.64	2156.84	2962.46	2708.77	18273.46
Slovenia	142.08	235.87	205.13	205.02	236.81	231.07	265.64	264.09	189.69	274.34	2249.73
Slovakia	226.93	486.83	563.39	655.27	678.90	571.94	560.31	529.35	562.53	643.91	5479.35
Finland	918.31	904.96	803.53	892.06	834.48	801.32	881.23	1489.19	949.53	963.10	9437.70
Sweden	1063.13	1049.73	881.87	1036.29	992.26	1000.19	884.87	915.27	876.63	937.14	9637.39
United Kingdom	4214.51	4231.39	3821.94	3939.84	3953.73	4056.75	4094.50	3933.04	3770.52	3968.11	39984.34
Total	48362.62	57593.76	54234.57	55048.48	56288.00	57889.59	57906.41	55191.35	56598.49	56521.64	555634.91

Source: European Commission reports to the European Parliament (Financial reports: EAFRD and EAGF 2018)

Table 2. Amounts received from EAFRD and EAGF funds (column 2). Pearson correlation coefficients between EAFRD and EAGF amounts and (a) agricultural outputs (column 3) and (b) GVA (column 4) for 2007 – 2016 period

Country	Received EAFRD + EAGF per country (million EUR)	r of output	r of GVA
Column 1	Column 2	Column 3	Column 4
Austria	12,420.94	-0.1137	-0.0333
Belgium	7,635.98	-0.8080	-0.1821
Bulgaria	6,913.23	**+0.7586**	**+0.7781**
Czech Republic	10,364.92	+0.5058	+0.5308
Cyprus	643.06	+0.4454	-0.2481
Denmark	10,532.63	-0.6868	-0.4987
Estonia	1,716.31	+0.4492	-0.0824
Finland	9,437.70	+0.1893	-0.1605
France	95,641.62	-0.2881	-0.1747
Germany	65,947.00	-0.4561	-0.3425
Greece	28,738.95	+0.4594	+0.3443
Hungary	14,930.96	+0.4601	+0.5422
Ireland	16,207.38	-0.5480	-0.4367
Italy	58,511.22	+0.3969	+0.2173
Latvia	2,685.12	+0.2789	-0.1568
Lithuania	5,266.17	+0.5452	+0.4885
Luxembourg	466.67	-0.8530	-0.4348
Malta	144.93	0.5110	+0.0422
Netherlands	10,412.71	-0.8474	-0.6591
Poland	40,865.99	**+0.7800**	+0.4896
Portugal	12,571.02	+0.5059	-0.2771
Romania	18,273.46	+0.3012	+0.1845
Slovakia	5,479.35	+0.1372	-0.1332
Slovenia	2,249.73	+0.3701	+0.1136
Spain	67,258.96	-0.2700	-0.4041
Sweden	9,637.39	-0.2018	+0.1025
UK	39,984.34	-0.2630	-0.2735

Source: Authors

Correlation between issued payments from the funds and both agricultural outputs and GVAs should be positive. That means that the money paid rendered foreseen effects – effecting increases and decreases relative to (in correlation with) the fluctuations of received amounts.

For agricultural output:

Results show that there are only two countries that have strong positive correlation (numbers in bold): Bulgaria and Poland. Countries that have moderate positive correlation (values in italic) are: the Czech Republic, Cyprus, Estonia, Greece, Hungary, Lithuania, Malta and Portugal. None have it very strong.

For agricultural GVA:

Results show that there is only one country that has a strong positive correlation (numbers in bold): Bulgaria. Countries that have moderate positive correlation (values in italic) are: the Czech Republic, Hungary, Lithuania and Poland. None have it very strong.

To facilitate reasoning and give conclusions, the authors used open source geographic information system QGIS. They wanted to prove that using this software tool could facilitate conclusions and cross-referencing of more than two determined variables. Figure 1 presents visualised spatial distribution of the values of total payments: EFARD plus EAGF during 2007-2016 period. It is obvious that major sums were

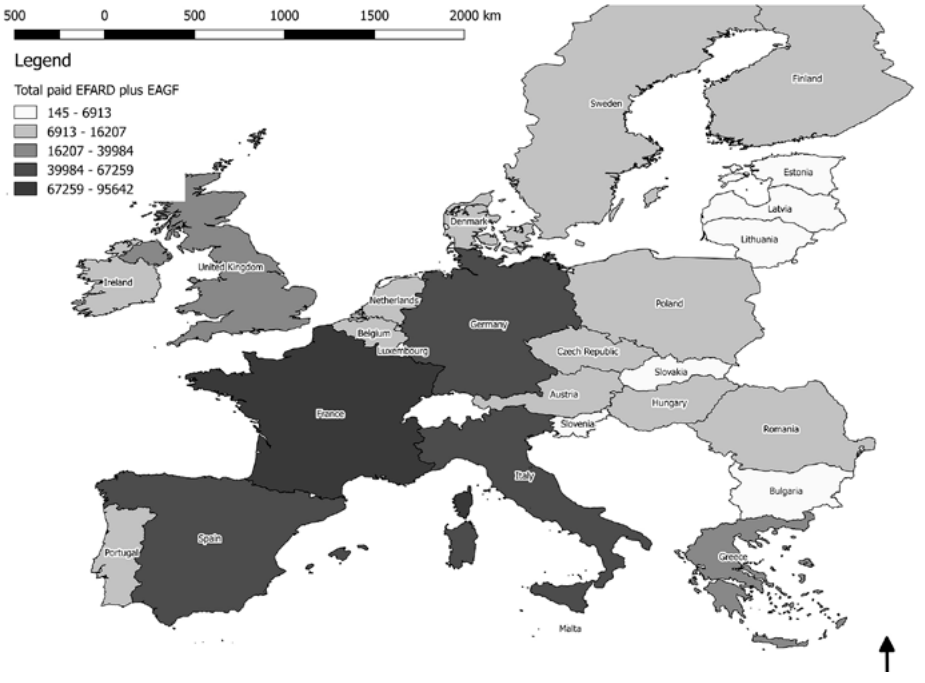

Figure 1. Visualised spatial distribution of the values of total payments: EFARD plus EAGF (2007-2016) categorized into 5 classes (darker colour = bigger payment)
Source: Authors

paid to old member states: the most to France, then to Germany, Spain, and Italy. Eastern EU countries received less money, particularly countries in transition or developing countries.

Figure 2 is a presentation of the correlation between total payments: EFARD plus EAGF during the period 2007 - 2016 categorized into 5 classes and the agriculture output with indicated values of correlation coefficient, and with GDP (gross domestic product) per capita. It is visible that countries with the biggest GDP per capita are less efficient with European money. East European countries use money in

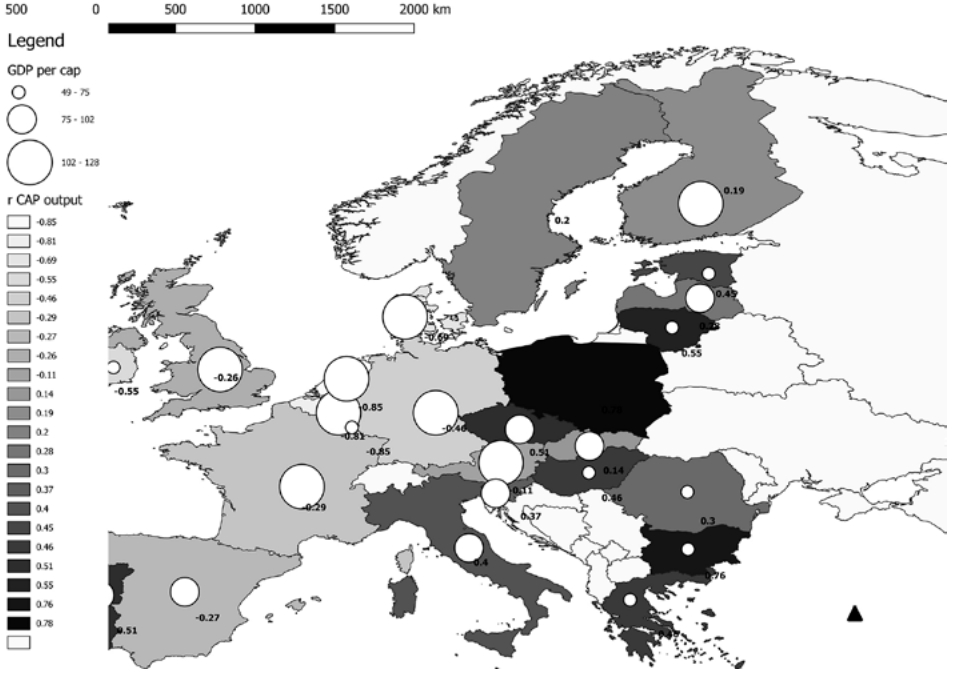

Figure 2. Visualised spatial distribution of the values of Pearson correlation coefficient between the EAFRD plus EAGF payments and the agriculture outputs (2007-2016) categorized into 5 classes (darker colour = higher correlation) with values of GDP per capita visualised by using different sizes of circles (bigger circle = higher GDP) (List of sovereign countries in Europe by GDP (nominal) 2018)
Source: Authors

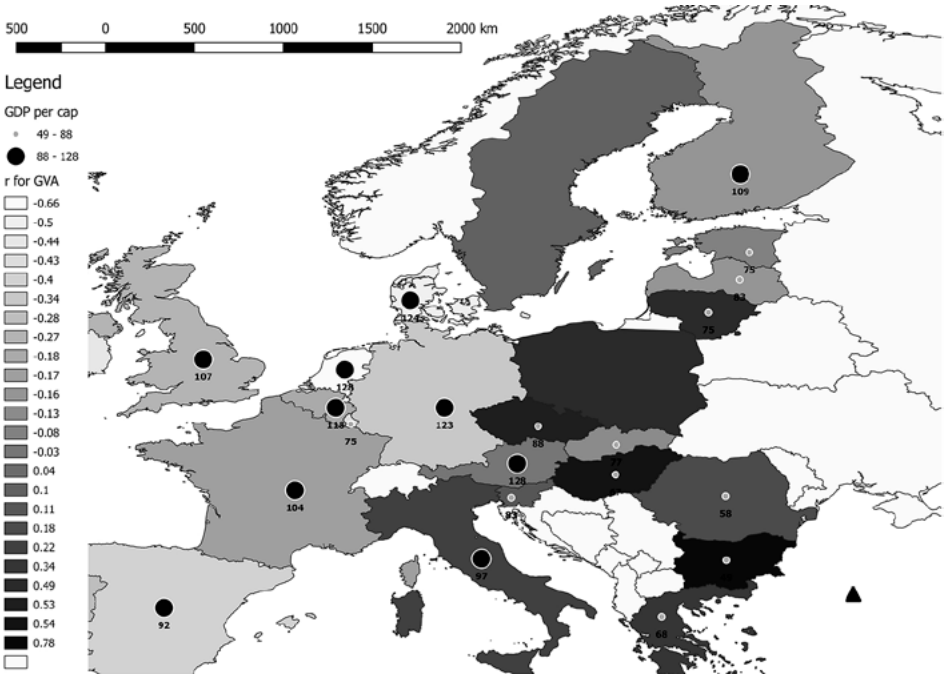

Figure 3. Visualised spatial distribution of the values of Pearson correlation coefficient between the EAFRD plus EAGF payments and the agriculture GVA (2007-2016) categorized into 5 classes (darker colour = higher correlation) with values of GDP per capita visualised by using different sizes of circles (bigger circle = higher GDP per capita) (List of sovereign countries in Europe by GDP (nominal) 2018)
Source: authors

a better way. Also, from Table 1, it can be concluded that only 2 (7.4%) of 27 EU countries have strong positive correlation between the agricultural outputs and the used EU agricultural funds, and additional 25.9% have moderate correlation. This refutes the H1 hypothesis.

As far as the GVA values are concerned, Figure 3 gives visual insight into spatial distribution of the Pearson correlation coefficient between total payments through EFARD plus EAGF during period 2007 - 2016 categorized into 5 classes and agriculture GVAs with indicated values of correlation coefficient, and with GDP per capita. And again, it is in favour of Eastern and central European countries.

Also, from the Table 1, it can be concluded that only 3.7% of 27 EU countries have strong or very strong positive correlation between the GVA and the used EU agricultural funds and additional 14.8% have moderate correlation. This refutes the H2 hypothesis.

Table 3 with all previously stated discussions, proves that the use of EAFRD and EAGF funds is least efficient among the most developed countries. Their use of EU funds is not responsible enough and creates even wider gap between highly developed and less developed EU member states. This refutes the hypothesis H3.

The rejection of the three posited hypotheses brings about discussions about better and faster tools for monitoring the use of EU funds. GIS as a software tool proved to be a good tool for fast reaction on outcomes of absorption of EU financing. The model that could be implemented is presented in Figure 4.

It consists of permanent collecting of significant data and yearly analysis by means of calculating correlation coefficients and spatial visualisations of data

Figure 4. Model for evaluating the effects of agricultural EU funds based on GIS methodology
Source: Authors

using GIS. All of which should be carried out by EU countries. This model will render data needed for correction of measures and provide basis for improvement of impacts of EU financial support.

Discussion

The authors of the paper have surveyed the effectiveness of EU funding in the agriculture sector. Statistical and geovisualised tools were used to analyse proposed hypotheses. QGIS took more variables that indicate system's performances into consideration, rather than only relying on mathematical models, in this case, spatial distribution and GDP per capita. Researchers have found a weak relationship between basic agricultural facts and spent EU funds. Results related to correlation between the allocated money and the agricultural output, and between the allocated money and the agricultural GVA have revealed that only 7.4% (2) of 27 EU countries have a strong positive correlation with agricultural output and only 3.7% (1) with agricultural GVA. That refuted the hypotheses H1 and H2 of the authors.

Furthermore, discussion regarding economic ranking of EU countries proved that less developed countries are more successful in using subsidies from EU funds, probably due to the fact that they more dearly appreciate EU assistance. Five of the most developed countries have negative correlation between appropriated funds and agriculture gross value added which shows that funds were not properly used. That refuted also the hypothesis H3.

Conclusion

Conclusions of authors are that the money spent through EAFRD and EAGF funds did not contribute to more profitable, effective and responsible development of agricultural sector within EU 27. Authors point to the problem of monitoring and presentation of European investments. Visualisation enables analysis of more variables at the same time and fast reactions on changes in performance and could be implemented for all EU funding programs.

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