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EMPIRICAL EVIDENCES REGARDING THE RELATIONSHIP BETWEEN INNOVATION AND PERFORMANCE IN THE AGRICULTURE OF EUROPEAN UNION

Oana COCA[1], Gavril ȘTEFAN[2], Marilena MIRONIUC[1]

[1]Alexandru Ioan – Cuza University of Iasi, 11 Carol I Boulevard, 700506, Iasi, Iasi County, Romania, Phone: +40232 201 454, Mobile: +40745 640 793, Emails: oanacok@yahoo.com, marilena@uaic.ro
[2]University of Agricultural Sciences and Veterinary Medicine ”Ion Ionescu de la Brad”, 3 Mihail Sadoveanu Alley, 700490, Iasi, Iasi County, Romania, Phone: +40232 407 515 Email: stefang@uaiasi.ro

Corresponding author: oanacok@yahoo.com

Abstract

Innovation in agriculture occurs in response to the requirements of increasing the competitiveness of the agricultural sector, given the intensification of social and political pressures on combating the climate changes effects and ensuring food safety. Through innovation in agriculture is seeking for new solutions to increase the performance of economic entities in this domain and also to ensure sustainable development of the agricultural domain. The conducted research involved, first, a theoretical approach based on reviewing the specialized literature, which allowed, later, devising an empirical study on the relationship innovation - performance in agriculture, at the European Union level (EU-28). To answer the research question, in the study there were used the following data analysis methods: multiple linear regression analysis, correlation analysis, comparative analysis. The main results of the study show that, in most countries, agriculture has recorded performance gains. The highest levels of performance were recorded in those countries characterized by a high rate of investment in research - development and education of agricultural entrepreneurs. From the analysis of statistical relationships between indicators appears a positive influence of innovation on the performance of agriculture. Also, the results show that improving the economic performance is inversely related to the improvement of the environmental performance of agricultural entities, whereas the adoption of measures to minimize the consumptions of inputs does not ensure economic performance as it should be.

Key words**:** *agriculture, European Union, innovation, performance*

INTRODUCTION

The study of Dogliotii et al. [7] highlights the importance of innovation in agriculture for increasing productivity in this sector. They estimate that within 40 years, agricultural production must increase by at least 70% to ensure the population's food requirements. Most technological innovations were created to help farmers to increase productivity and quality of agricultural production and the latest innovation challenges are to reduce the environmental impact. Previous studies have identified at farm level, key features that influence innovation capacity, namely: resistance to shocks acting on the market, management solutions diversity of the shocks and flexibility in using available resources [6][10]. Market shocks that may occur are related to environmental protection [9], the legislative changes [12], the changes in consumer behavior [11].

Some researchers confirm the need for continuous innovation to achieve sustainable development of agriculture so as to achieve higher agricultural productions and to reduce the impact on environmental [16][30]. Since the decision of economic actors to engage in innovation activities is directly related to performance increase [24][32], it becomes important to analyze the relationship between innovation and performance in agriculture.

Based on the results and records of specialized studied literature, the paper aims to analyze the relationship between innovation and performance at the level of agriculture of

European Union member states (EU - 28).

From the literature review, we extracted the following conclusions on the impact of innovation on the performance of agriculture: i) innovation increases the productivity of factors [4][7][19]; ii) innovation reduce the dependence of agriculture to the natural factors, less controllable, with a positive effect on economic performance [20][2][18]; iii) innovation processes involves reduction of production costs from agriculture [28][17]; iv) innovation has a positive impact on the growth of the company's environmental performance by promoting resource conservation practices [14]. Based on these approaches on the relationship between innovation and performance, we intend to test the first hypothesis of research, namely: *H1: There is a strong and direct correlation between a country's agriculture performance and its innovative capacity in the field.* Numerous studies in the field have attributed to research in agriculture, a basic role for development of new solutions to increase agricultural productions [21][33], reducing the impact of natural factors on agricultural production [29][31] and increasing the degree of exploitation of natural resources [22]. Research - development activities (R&D) are the basis of the innovation process and the level of allocated expenditure to these activities directly influence the innovative capacity in the agriculture field and hence its performance [23][3][15].

Based on these approaches of researchers mentioned above, we formulated the second research hypothesis which we want to test:

H2: Increasing research - development spending favors the growth of agriculture`s performance.

MATERIALS AND METHODS

The research methodology was based on developing an empirical study on the relationship innovation - performance in agriculture at the level of the all 28 member states of the European Union (EU-28) by using the information available in Eurostat statistics [8]. Analysis period was chosen based on the availability of statistical data for all 28 EU countries. Whereas a part of indicators of appreciation of the innovation and performance of agriculture is calculated every 2 or 4 years (technical charging per tractor, degree of utilization of renewable resources in farms etc.), analysis was performed for 2006, 2010 and 2014 years. Comparative analysis of indicators for a four-year period highlights their long-term trend.

To answer research questions, the following methods were used for data analysis: linear regression analysis, correlation analysis, comparative analysis.

Discussion of variables

The dependent variable which reflects the performance of the agriculture`s field entities is the "*standard output per hectare*" (SO). This indicator is calculated as ratio between the total value of standard agricultural production or output and total used agricultural area (UAA). The total value of standard output relates to vegetable sector and does not include livestock production.

Closely related to research hypotheses, we selected the independent variables that can express the innovation influence on variation of dependent variable. The indicators included in the analysis were classified into indicators of agricultural innovation capacity and indicators of agriculture`s performance.

Indicators of agricultural innovation capacity

Technical charging per tractor (ITeh) expresses the number of hectares of farmland corresponding to a tractor and is calculated as a ratio between total utilized agricultural area and total number of tractors.

The share of agricultural area operated by managers with higher agricultural education in total UAA (Psup) is calculated as a ratio between the area exploited by managers with higher agricultural studies and total utilized agricultural area.

The human resource engaged in research and agricultural technology field per 1,000 people employed in agriculture (RH) is an indicator that characterizes the potential ensure of management of innovation process from agriculture domain. The indicator is calculated as the ratio between the total number of people aged between 25 and 64 who have higher agricultural study and/ or are working in research and agricultural technology domain and total number of people employed in agriculture multiplied by 1,000.

The share of R&D expenditure in agricultural gross value added (VAB) (Pcd) is an indicator that expresses as a percentage, the financial costs of public and private funding destinated to activities of research - development in agriculture of total agricultural gross value added generated at country level.

The share of organic farming area in total UAA (PEc) indicates the farmers`s adoption of innovations based on conservation of natural resources and protecting the environment, that helps to combat the negative effects of climate change. The indicator is calculated as a percentage ratio between agricultural land cultivated in ecological system and total UAA.

The degree of utilization of renewable resources in farms (Reg) is an indicator calculated as a percentage ratio between the utilized agricultural area exploited by farms owning equipments for producing energy from renewable sources (wind, solar, hidropower, biomass, biogas and other resources) (Sreg) and total UAA.

The share of arable area exploited in conservation/ no tillage system, in total arable area (Pmin) expresses the degree of adoption by farmers of innovative practices for soil conservation, for reducing the agricultural inputs and streamlining of fuel consumption. The indicator is calculated as a percentage ratio between arable land exploited in conservation system/ no tillage and the total arable area.

Indicators of agriculture`s performance

The share of agricultural gross value added in total GDP (VABa) shows the relative importance of the agricultural sector to form economic wealth of a country. The indicator is calculated as a percentage ratio between agricultural gross value added and total gross domestic product (GDP). A low relative importance of this sector indicates a high level of economic development [5].

The annual labor productivity (Wm) expresses the agricultural gross value added obtained per annual work unit (AWU), respectively is the newly value created by an full-time worker (employee or non-employee) of the agriculture field.

The indicator is calculated as a ratio between agricultural gross value added and the total number of annual work units.

The emissions of greenhouse gases (Ges) indicate the level of environmental performance of agriculture.

This indicator is calculated as a ratio between the total amount of emissions of greenhouse gases from agriculture and total UAA.

The reduction of this indicator may signal the implementation of technological innovations based on streamlining of agricultural consumption and management of agricultural wastes.

The consumption of NPK chemical fertilizers per hectare (Qig) express the level of chemical processing of agriculture and a high value of it can simultaneously increase agricultural production and cause the increases in pollution and quality reduction of agricultural products. The indicator is calculated as a ratio between the total quantity of active substance of chemical fertilizers NPK and total UAA.

The indicators included in the analysis are presented in Table 1.

The links between the chosen variables were tested by applying correlation analysis and multiple linear regression analysis.

Determining the intensity and meaning of statistical connections between numerical variables (x, y) was achieved by calculating the *Pearson correlation coefficient (r) (rxy)* and the *Pearson correlation report (R).* The existence of a statistical link between the variables was tested applying the *Student t test*.

Further was measured the degree to which the dependent variable *"x"* (standard output per hectare - SO) is explained by the independent variables chosen through multiple linear regression analysis. The data was processed using *IBM SPSS software functions - Version 20.*

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Table 1. Evaluation indicators of innovation and performance in agriculture

Category	Indicator	MU	Symbol
1. Indicators of agricultural innovation capacity	1.1 Technical charging per tractor	ha/ tractor	ITeh
	1.2 Share of agricultural area operated by managers with higher agricultural education in total UAA	%	Psup
	1.3 Human resource engaged in research and agricultural technology field per 1,000 people employed in agriculture	people	RH
	1.4 Share of R&D expenditure in agricultural VAB	%	Pcd
	1.5 Share of organic farming area in total UAA	%	PEc
	1.6 Degree of utilization of renewable resources in farms	%	Reg
	1.7 Share of arable area exploited in conservation/ no tillage system, in total arable area	%	Pmin
2. Indicators of agriculture`s performance	2.1 Standard output per hectare	euro/ ha	SO
	2.2 Share of agricultural gross value added in total GDP	%	VABa
	2.3 Annual labor productivity	euro/ AWU	Wm
	2.4 Emissions of greenhouse gases	tonnes / ha	GES
	2.5 Consumption of NPK chemical fertilizers per hectare	kg a.s. / ha	Qig

Source: own contributions

RESULTS AND DISCUSSIONS

The analysis of relations between innovation and performance in the agriculture of the European Union member countries included the following research steps: i) descriptive and in dynamic analysis of indicators; ii) the statistical analysis of the relationships between indicators. We present below the main results obtained in the two phases of the study.

The descriptive and in dynamic analysis of indicators

Following the verification of the normality of analyzed variables, resulted the need of logarithmating of normally undistributed variables, so as to ensure the validity of correlation and regression analyzes.

Characterization of selected distribution variables was performed using descriptive statistics (Table 2).

Table 2. Descriptive statistics of variables

Variables	N	Min.	Max.	Mean	Std. Dev.
Technical charging per tractor	84	4.34	117.46	33.45	24.84
Share of agricultural area operated by managers with higher agricultural education in total UAA	82	.47	81.89	30.36	22.02
Human resource engaged in research and agricultural technology field per 1,000 people employed in agriculture	78	21.67	613.54	169.31	105.94
Share of R&D expenditure in agricultural VAB	84	.32	18.52	4.65	4.33
Share of organic farming area in total UAA	84	.10	19.50	5.79	4.48
Degree of utilization of renewable resources in farms	84	.01	66.39	9.25	15.41
Share of arable area exploited in conservation/ no tillage system, in total arable area	84	.23	62.50	35.74	16.27
Standard output per hectare	84	163.11	5595.03	1300.61	1006.12
Share of agricultural gross value added in total GDP	84	.21	7.18	1.60	1.22
Annual labor productivity	84	920.99	51102.41	10723.59	11622.99
Emissions of greenhouse gases	84	1.09	10.08	3.17	2.25
Consumption of NPK chemical fertilizers per hectare	83	20.64	189.27	84.71	37.54

Source: own contributions

It can be noted from Table 2 that the highest value of standard output per hectare was 1,584.17 euro/ ha, this being registered by Italy in 2014, and the lowest value of standard output was registered by Estonia in 2006 of 269.91 euros/ ha. The high values of the standard deviations indicate large differences between the surveyed countries, in terms of performance of agricultural activity and of innovation activities.

The best economic performance was registered by commercial farms in Italy, which achieved a standard output of more than 1,400 euros per hectare each year. There is a growing trend of this indicator from one period to another, in most countries under review, as a result of the implementation of more productive technologies and of an efficient organization of work.

The productivities per hectare from Romania, Estonia, Finland and Latvia have the lowest values, less than 600 euro/ ha.

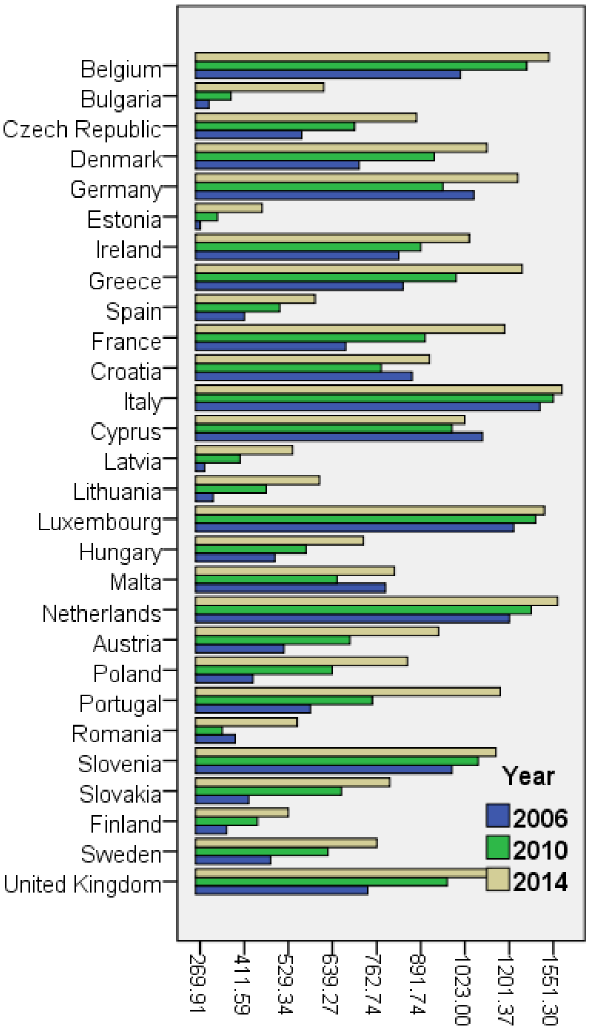

Fig. 1. The value of standard output per hectare (euro/ ha), EU-28 (processing after Eurostat)

We notice the unexpected presence of Northern countries among laggards on productivity, a phenomenon that can be explained by the fact that these countries are specialized in animal husbandry (especially pig breeding), and vegetable farming area has a reduced representation. In relative terms, the largest increases in the 2006 - 2014 period were recorded by Poland (104.31%) and Portugal (98.60%).

We present below the main results from the descriptive and in dynamic analysis of the indicators expressing the innovative capacity and performance of this sector in EU countries.

A first indicator that denotes the potential for innovation in agriculture is the *"technical charging per tractor*". A very high level of technological endowment is registered by countries like Slovenia, Malta, Austria and Cyprus with a tractor charging of less than 10 hectares. These values may reflect, on the one hand, a high potential of increasing yields in production technologies or can express the "underutilization" of technical capital, the increased of fixed costs with amortization and maintenance of technical capital, which have negative effects on economic efficiency, on the other hand. The lowest levels of endowment with tractors are registered in 2014, by Bulgaria (73 ha/ tractor), Slovakia (70 ha/ tractor) and Romania (69 ha/ tractor). In the analyzed period the technical charging per tractor decreased in all EU countries, except Greece. To determine the optimal charging on tractor, depth studies are needed at the micro level, to analyze the efficiency of investment in those capital goods that attract technical progress.

Along with technical capital used in agriculture, the human capital is a very important innovation resource for insurance of generation capacity of innovative ideas, for engaging in research - development and successful implementation of innovations. According to Eurostat, the highest percentage of areas exploited by managers with full agricultural studies were recorded in 2014 in the Czech Republic (77.00%), Luxembourg (67.00%), Slovakia (57.68%) and Latvia (55.18%). The largest absolute increases were recorded, in the period 2006 – 2014, by Latvia (11.79%) and Poland (9.92). Access to

information is facilitated by innovation and human capital, which is why the development potential of agronomic sector of a country is directly linked to the education of the farmers.
The lowest shares of areas exploited by managers with higher education in agriculture were registered in 2014, by Greece (0.89%), Cyprus (1.56%) and Malta (2.3%). About 17% of the agricultural land in Romania is exploited by entrepreneurs with full education in the field, which ranks Romania over Italy (11.90%), the Netherlands (12.09%) and other richer countries.

Another indicator that expresses the quality and the innovative potential of the human resources in agriculture is *the number of people engaged in research and agricultural technology field*. As analyzed, the highest levels of human capital endowment per 1,000 persons employed in agriculture, were registered in 2014 by United Kingdom (613 people), Germany (332 people) and Finland (309 people). The lowest values were recorded in 2014, by Greece (41.59 person/ 1,000 persons employed in agriculture), Romania (59,45 persons/ 1,000 persons employed in agriculture) and Portugal (68,69 persons/ 1,000 persons employed in agriculture). The overall trend, noticeable for the analyzed countries, is the growth of this indicator from one period to another, which can positively influence the growth of economic performance of the agricultural sector.

The macroeconomic indicator most used for general characterization of the innovation potential in an area is the share of research - development costs in the country's GDP.

Considering the analyzed field, we calculated based on Eurostat and OECD statistics, "*the share of R&D expenditures, in agricultural gross value added"*. In such countries as Denmark, Belgium, the Netherlands and Finland, the R&D expenditure represents more than 10% of the gross value added of the agricultural sector.

The lowest rates of investment in research were recorded in 2014, by Romania (0.56%), Bulgaria (0.96%) and Slovakia (1.12%), with negative effects on farm development and competitiveness on the international market. In Romania, it has recorded an absolute increase of this indicator by 0.24%, from 0.32% in 2006 to 0.56% in 2014. The increase of this percentage may be the effect of research - development project implementation, financial supported by the European Operational Programs carried out during 2007-2013. During that period of time, were funded 39 research – development - innovation projects in agriculture, by the Sectoral Operational Programme “Increase of Economic Competitiveness 2007-2013“, with a total value of 85 million euros.

The efficiency of investment in research is influenced by the involvement of both public research organizations and private economic actors. Increasing the private sector involvement in research is driven by EU policies through the allocation of grants for research projects carried out by various partnerships between these categories of economic actors. For example, Romania dispose during 2014 – 2020 of one billion euros to fund research - development projects through the National Rural Development Programme - Measure 16 - Cooperation (EUR 31 million) (dedicated only to agriculture and agri-food industry) [25], Regional Operational Programme 2014-2020 - Priority Axis 1 - Technology Transfer (EUR 175 million) [27] and the Competitiveness Operational Programme 2014-2020, Priority Axis 1 - Research, technological development and innovation (RDI) (EUR 798 million) [26].

Analysis of relations between innovation and performance also included the conversion degree to organic farming. *The share of organic farming area in total UAA* indicates the farmer`s adoption of innovations based on conservation of natural resources and on protecting the environment, helping to fight against the negative effects of climate change. These also contribute to enhancing product quality and, thus, the selling price, with positive effects on business performance [31].

During the analyzed period, the countries that stood out by a share of over 10% of organic land are Austria, Czech Republic, Sweden and Estonia. The lowest percentages in organic crop (under 3%) were registered in Bulgaria, Malta and Romania.

One of the major constraints for farmers to grow organically is the lack of stable and less elastic price markets. The food consumption is characterized by high elasticity to price, especially in underdeveloped countries with a low purchasing power.

The degree of utilization of renewable resources in farms is an indicator which shows a certain degree of independence of farmers to conventional energy resources, with positive effects on lowering the production costs and increasing the environmental efficiency of agricultural technologies. The highest degrees of equipping for power generation from renewable sources were recorded in Finland (66.39%), Denmark (62.38%) and Luxembourg (59.92%). The lowest shares of renewable resources use, of less than 1%, were attained on farms in Romania, Bulgaria, Cyprus, Greece and Ireland. We appreciate that these countries have low environmental performance and does not contribute enough on combating climate change.

The main factors that constrain the use of renewable resources in these countries are represented by the lack of financing for such investments, the still low interest of farmers for protecting the environment and the difficulties in assessing the impact of new installations on economic and environmental performance.

The share of arable area exploited in conservation/ no tillage system, in total arable area express the adoption degree of innovative practices to conserve resources, among farmers. These practices fall under the category of process innovations, intensively studied by researchers [1][13]. The highest rates of exploited areas in the minimum work system or without tillage were registered in countries such as Finland, Sweden, Ireland and Bulgaria (50-60%). The lowest weights of soil conservation technologies adoption were recorded in Malta (8.80%), Denmark (15.60%) and Hungary (20.12%). In Romania, over 25% of arable land is cultivated in conservation or no tillage system. The overall trend shows the growth of this indicator from one period to another.

The share of agricultural gross value added in total GDP shows the nation's dependence on agriculture. The most significant absolute reductions of the relative importance of agriculture in the economy were registered in Romania (3.02%, from 7.73% in 2006 to 4.71% in 2014) and Bulgaria (1.55% from 6.12% in 2006 to 4.57% 2014). Nevertheless, the two countries continue to register the highest percentages for agriculture`s participation in GDP (over 3%), reflecting a strong dependence on agriculture and a lower level of economic development.

In countries like United Kingdom, Germany, Luxembourg and Belgium, the agriculture participates with less than 1% of gross domestic product. The formation of gross value added in European Union agriculture is dominated by four countries that together form 53.60% of total gross value added, as follows: France (16.7%), Italy (15.9%), Spain (12.0%) and Germany (9.0%). These countries have a rich tradition in agriculture and are characterized by large agricultural areas, an advanced level of technologies and a strong subsidizing of farmers. The four countries together form 45.7% of the utilized agricultural area in the European Union (174.6 million hectares). Romania participates with only 3.6% to the gross value added in agriculture of EU-28 and holds 7.5% of the total utilized agricultural area.

The annual labor productivity is an indicator of labor efficiency in the production process. At EU level, the average annual labor productivity was in 2014 of 12,481.60 euro/ AWU, up 34% compared to 2006 (9,341.76 euro/ AWU). Very high levels of labor productivity were registered in 2014 by Nordic and Western Europe countries, respectively the Netherlands (51,102 euro/ AWU), Denmark (37,841 euro/ AWU), France (31,635 euro/ AWU) and the United Kingdom (27,700 euro/ AWU). Labour productivity growth is directly related to technologies and the general level of economic development of the country. The lower labor productivities were registered in Eastern countries, namely in Romania (1,079 euro/ AWU), Latvia (1,306 euro/ AWU), Poland (2,372 euro/ AWU) and Hungary (3,019 euro / AWU).

The emissions of greenhouse gases indicate the environmental performance of agriculture and a low amount of emissions reflects a reduced impact of farming on the environment. Can noticed that the lowest emissions of greenhouse gases from agriculture were registered, during 2014, in Bulgaria (1.09 tonnes/ ha), Romania (1.29 tonnes/ ha), Lithuania (1.36 tonnes/ ha) and Estonia (1.38 tonnes/ ha). These results indicate a reduced intensification of agriculture, which has positive effects on environmental protection, but with possible negative effects on economic performance. Significant gas emissions from agriculture were recorded in Netherlands, Belgium, Malta and Cyprus, for more than 8 tonnes/ ha.

The previous indicator is in direct correlation with *the consumption of chemical fertilizers per hectare,* the latter being a main source of nuisance in agriculture, along with livestock manure. The amount of NPK chemical fertilizers per hectare express the level of chemical intensification of agriculture, and a high value thereof can simultaneously increase agricultural production, grow environmental pollution and decrease the quality of agricultural products. The biggest consumers of fertilizers, with more than 130 kg of NPK active substance per hectare, are the farmers from Belgium, the Netherlands and Malta. These three countries have the highest emissions of greenhouse gases from agricultural activities, within the EU. Small amounts of chemical inputs are used in holdings from Romania, Portugal, Luxembourg and Latvia (under 50 kg of NPK active substance per hectare).

Statistical analysis of the relations between indicators

Based on the information described in the previous section, we further conducted an analysis of statistical correlation and regression relation of indicators. Variables that did not show a normal distribution were transformed by logarithm. The results of correlation analysis of the dependent variable *"standard output per hectare"* with the independent variables were presented in Table 3.

Table 3. Testing the correlation between variables

Indicatori		SO
LN_Technical charging per tractor	*Pearson C. (r)*	-.449**
	Sig.	.000
Share of agricultural area operated by managers with higher agricultural education in total UAA	*Pearson C. (r)*	-.175
	Sig.	.115
LN_Human resource engaged in research and agricultural technology field per 1,000 people employed in agriculture	*Pearson C. (r)*	-.001
	Sig.	.996
Share of R&D expenditure in agricultural VAB	*Pearson C. (r)*	.329**
	Sig.	.002
Share of organic farming area in total UAA	*Pearson C. (r)*	-.096
	Sig.	.385
Share of arable area exploited in conservation/ no tillage system, in total arable area	*Pearson C. (r)*	-.003
	Sig.	.976
LN_Share of agricultural gross value added (VABa) in total GDP	*Pearson C. (r)*	-.322**
	Sig.	.003
LN_Annual labor productivity	*Pearson C. (r)*	.584**
	Sig.	.000
LN_Degree of utilization of renewable resources in farms	*Pearson C. (r)*	.346**
	Sig.	.001
LN_Emissions of greenhouse gases	*Pearson C. (r)*	.639**
	Sig.	.000
Consumption of NPK chemical fertilizers per hectare	*Pearson C. (r)*	.361**
	Sig.	.001

**. Correlation is significant at the 0.01 level.

The *Pearson* correlation coefficients (r), whose values, in module, are greater than 0.300 (with sig <0.01), are indicating the existence of moderate links between indicators. Thus, we see that there is a direct correlation between standard output per hectare (SO) and the following independent variables: the emission of greenhouse gases (r=+0.639); the annual labor productivity (r=+0.584); the amount of NPK chemical fertilizers per hectare (r=+0.361); the utilization of renewable resources in farms (r = +0.346) and R&D expenditure share in VABa (r=+0.329). This shows that the economic performance of agriculture is still dependent on the level of intensification of agriculture with chemical inputs, but also on the level of research – development investments in agriculture field. A high share of renewable indicates the presence of process innovations, which act on reducing operating costs and increasing environmental and economic performance of the company. Also, a good supply of agriculture with high trained specialists, namely those who have full education in agricultural sciences or are working in research and agricultural technology, directly correlates labor productivity (r=+0.502) which aims at increasing performance. According to conducted analysis, there is a moderate inverse correlation between the standard output per hectare and the indicators: technical charging per tractor (r = -0.449) and share of agricultural gross value added in total GDP (r=-0.322). Mechanization and automation of farm processes are important elements in growing the agriculture performance because these reduce the time and costs required to perform agricultural works. Regarding the environmental performance, a low level of technical equipment correlates inversely with increasing the amount of greenhouse gases (r=-0.459), positively influencing the environment. We notice that a high performance in agriculture is obtained in countries with a low level of dependence on agriculture, which has a small contribution to national wealth formation (below 3%).

Regarding the training level of managers in the agricultural field, there is a direct correlation with the share of organic farming area (r=+0.300) and technical charging per tractor (r=+0.402). In other words, an educated manager who followed an academic training in agriculture is more attracted by the quality of organic production and environmental protection, than getting large amounts of conventional products.

The share of R&D expenditure in total agricultural gross value added is in a strong direct correlation with labor productivity in agriculture (r=+0.721) and the use of renewable resources (r=+0.621). It thus shows that innovation involves increasing the leverage of labor resources and energy.

Economically highly developed countries, among which agriculture has a relative importance of less than 2-3%, have a greater interest in technological innovations to reduce the environmental impact.

Given the dependent variable "standard output per hectare", it was analyzed the effect of the determinants on it, applying the *multiple linear regression analysis*.

Table 4. Regression equation of the dependent variable "standard output per hectare"

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	228.685	69.842	.612	2.829	.001		
	Share of R&D expenditure in agricultural VAB	21.489	1.462	.254	5.485	.001	.342	2.921
	Share of arable area exploited in conservation/ no tillage system, in total arable area	-2.741	1.575	-.124	-1.740	.018	.920	1.087
	LN_Technical charging per tractor	-145.802	36.962	-.321	-3.945	.000	.713	1.402
	LN_Annual labor productivity	170.228	36.688	.540	4.640	.000	.379	2.638
	LN_Emissions of greenhouse gases	291.208	72.939	.468	3.992	.000	.348	2.876
Dependent Variable: Standard output per hectare (euro/ ha)								

$$SO = 228,685 + 21,489Pcd - 2,741Pmin - 145,802LN\ ITh + 170,228LN\ Wm + 291,208\ LN\ GES + \varepsilon$$

Note: The interpretation of regression coefficients with independent variables transformed by logarithm is performed after their transformation: $\beta_1 x \ln(101/100)$

Multiple regression analysis was based on *Backward* method, which involved the introduction of the 11 variables in the model, and gradually eliminating the independent variables which presented multicolinearity (were correlated with other variables in the model). According to the final model, it resulted the regression equation for the dependent variable as shown in Table 4.

The resulting regression equation after

logarithmic transformation of variables is as follows:

$$SO = 228{,}685 + 21{,}489Pcd - 2{,}741Pmin - 1{,}451\ ITh + 1{,}694Wm + 2{,}898GES + \varepsilon$$

Analyzing the equation we see a positive influence of research - development spending ratio, labor productivity and emission of greenhouse gases on increasing agriculture performance, as measured by standard output per hectare. An increase in the R&D expenditure ratio by one unit will get an increase of 21.489% of the standard output per hectare. This relationship shows a very high dependence of agriculture`s economic performance so far as it invests in research, both at the public, and especially at the private economic level. Considering that labor productivity is directly related to attracting technical progress, we can reassess a positive influence of innovation on increasing agriculture`s performance. We also note that intensive technologies, consuming large quantities of inputs and producing high amounts of greenhouse gases positively influence a high level of economic performance. This relationship is evidenced by the negative value of the regression parameter for the share of arable area exploited in conservation/ no tillage system (β=2.741). Thus, following the model, an increase of one unit of the share of arable area exploited in conservation/ no tillage system will decrease to 2.741% the standard output per hectare. Limiting the number of agricultural work has benefits on soil structure and composition, by stimulating the biological activity in the soil, reducing soil erosion and increasing water storage. The influence of technical charging per tractor on economic performance is reversed, and one unit increase of the technical charging (a hectare) causes a decrease of standard output of 1.451%. It follows that the technical endowment of farms with more efficient tractors and incorporating an innovative technology is needed to ensure the growth of economic performance indicators. Based on these results we can say that improving economic performance is inversely related to increasing the environmental performance of agricultural entities, whereas the adoption of measures to minimize the consumption of inputs does not ensure the suitable economic performance.

CONCLUSIONS

By analyzing the macroeconomic key indicators characterizing the European Union agriculture revealed that in most countries, agriculture has seen performance gains, especially in those countries that have high rates of investment in research - development and in farmers education (such as Belgium Luxembourg, Sweden, the Netherlands). The dependence of nations on agriculture has decreased in most countries, a fact that supports economic growth and development.

Although Romania has significant natural resources for agriculture (7.5% of EU-28 agricultural area), the level of economic performance is low, with labor productivity far below the EU average and with low investment in research - development activities. Analyzing the statistical relationships between the indicators, it turns out that innovation has a positive influence on the agriculture performance, through increased spending for research - development - innovation and increased supply of specialized labor resources.

We appreciate that the analysis results support the validity of research hypothesis *H1: There is a strong and direct correlation between a country's agriculture performance and its innovative capacity in the field* and *H2: Increasing research - development spending favors the growth of agriculture`s performance.*

We consider the researchers and specialists in agriculture should focus on developing innovations that provide increased technical yields, raise the product quality and, consequently, their added value, under conditions of a reduced impact on the environment.

The research results helps us to better understand the impact of agricultural innovation capacity on the performance of this economic sector. This study may be a reference in decision making of innovation investment at farm level, on the one hand, and the decisions on the macroeconomic level, resulting in policies of growth and development of the agricultural sector at international level, on the other side.

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