STUDIES

Effect of agricultural research & development on the GDP of EU member states

Mohamed, Susanne – Takács, Szabolcs
Szűcs, István – Bedéné Szőke, Éva

Keywords: EU, R&D intensity, production functions, combination of production factors.

SUMMARY FINDINGS, CONCLUSIONS, RECOMMENDATIONS

Scientific research, together with technological development and innovation, is a key issue of knowledge-based economies. Having recognized this important role, the European Union has identified the increasing of its research budget to be one of its most important aims. The objective of the common programming of agricultural research is to examine the extent to which society is able to answer the challenges resulting from the Community-level development of renewable raw materials.

Joining in the spirit of these endeavours, the aim of our research is to analyze the links between agricultural R&D expenditure and agricultural GDP in the EU member states, relying on the Eurostat database. Our computations were made using constant prices of 2000. The results of our calculations can be summarized as follows:

• The C-D type functions are useful for measuring the approximate impact of the production factors we analyzed.

• In 2000 it was the agricultural assets, and in 2007 the labour, which had a greater contribution to the agricultural GDP. This change indicates that in the meantime, the labour force had acquired more technical expertise, i.e. had accumulated a greater knowledge, and its significance as a production factor had increased.

• The share of agricultural R&D in the production of GDP was approximately 11% in 2000 and 14% in 2007, thus the development efforts are essential from the point of view of agricultural production.

INTRODUCTION

"In efficiency-oriented societies, the results of all activities are taken into account, their yields, weaknesses as to be stated, parallel will be drawn between inputs and outputs, as well as between cost and benefit and it will be examined, if it is worth continuing the given activity. The scientific research cannot be an exception either"[1]. The research-performance can be measured on different levels: those of individuals, of research communities, of science field, of country, etc. Generally, the different measurement indicators are determined on the basis of publications and references.

[1] (mhtml:file://G :tudománymetria,.mht)

It doesn't need any explanation that regarding to the aspect examined by us, the question is a special interpretation of the efficiency of research activities, which is different from the general evaluation made generally in the framework of scientometry for the efficiency of those activities.

The measurement of effects of R&D activity and of technical development on agricultural productivity has a relatively abundant reflection in economic literature. Now, we would like to emphasize three characteristic examples from this rich literature.

In 1999 *Ádám Török and Raymund Petz* examined the interrelation between R&D activity and export structure in the Hungarian economy. They analyzed the role of R&D expenditure in the development of efficiency improvement of Hungarian industry. As a result of their calculations made by means of production functions, they stated as follows: "The influence of R&D activity in the transformation of export-structure is clear and evident... the concerted shift in R&D intensity and in export orientation, as well as in export-import proportions has a positive direction." (*Török – Petz, 1999, pp. 213-230*)

In 2004 *Thirtle and al.* worked out new measurement techniques. The availability of long time-series has considerably improved the measurability of full factor efficiency (TFP) in agriculture. The authors analyzed the development of TFP in agriculture of EU member-states by means of time-series. The production function of *Thirtle and al.*, containing lagged elements is as follows:

$$LnTFP_{1=}\beta_{0+}\beta_1 Ln(K+F)_{t-i} + \beta_2 LnMP_{t-j} + \beta_3 LnCP_{t-k} + \beta_4 LnFS_t + \beta_5 DUM_t + \varepsilon,$$

where the R&D is lagged behind by "i" years, by "j" technical patent years (MP) and by "k" chemical patent years (CP). The farm size isn't taken into account, and the DUM is a blank (dummy) variable. This equity applies point estimations to find those lags, which have the greatest influence in the TFP, as well as to filter out those lags, which are not significant. They stated that the increment of TFP in the agriculture of EU had been slow in the last two decades, as it is clearly shown in the international comparisons. The changes in TFP are explicable by public and private technologies (innovations) and by returns to scale (*Thirtle et al., 2004*).

In 2008 the interrelation between the Hungarian agriculture and R&D activity was analyzed within the favored research program NKFP-2004/4/14, i.e. it was examined, what kind of role the technical extension and the changes in return to scale played in the development of most important branches of the Hungarian agriculture. The computations were made by means of *Tomquist and Malmquist* indices (*Szűcs – Fekete, 2008, p. 205.*). Methodically, the analysis was made using different types of production functions. The application of such functions has a very rich Hungarian and international literature. They are applied successfully first of all for the examination of agricultural production, production factor, average- and marginal productivities, or of the elasticity of substitution, where success of production is influenced by lot of factors. (Among the agricultural appliers of these functions, the activities of *Csáki, Cs., Andrássy, A., Tóth, J., Szűcs, I., Spitálszky, M., Farkasné Fekete, M., Bertold, J., Akobundu, E., Breimyer, H.F., Davis, G.C., Salhofer, K., Traill, W.B., Pfefferman, D., Barnard C.H.* can be mentioned.)

1. DATA BASE OF PRIMARY EXAMINATION

In the course of our research work, we have analyzed the interrelation between agricultural R&D intensity and economic development. In the calculations, we have relied on the primary data issued by Eurostat for 2000 and 2008, or on information derived from these data.[2]

Countries drawn into examination have been: Belgium, Bulgaria, Czech Republic, Denmark, the Netherlands, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Lithuania, Latvia, Luxemburg, Hungary, Malta, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, the United Kingdom, Croatia, Macedonia, Turkey, Iceland, Norway, Switzerland, US, Japan, Canada, altogether 36 countries, plus the average data. Thus, we have analyzed some countries beside the EU member states in order to be able to interpret the interrelations with a greater accuracy, or even in order to dispose a larger data set for the fitting of production functions. We have worked with the following data:

– per capita GDP, €;

– per capita R&D expenditure, €;

– agricultural GDP expenditure, million €;

– unit agricultural R&D expenditure, thousand €/hectare;

– total R&D expenditure, million €;

– total value of fixed assets, million €;

– total staff, thousand men;

– total number of patents, pieces/thousand men;

– number of biotechnological patents, pieces/thousand men.

Some remarks on data collection: Research and development expenditure: comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society and the use of this stock of knowledge to work out new applications. Research and development are characterized by the presence of the following fundamental elements: the elements of creation, the element of novelty, the adaptation of scientific methods and creation of knowledge.

Observation units of R&D survey are the units performing R&D activities irrespective of their organizational form. Sectoring of the units are the following: government sector, business enterprise sector, higher education sector.

Calculated staff number (Full time equivalent): The actual staff number converted to full-time employees, i.e. staff number weighted with the ratio of time spent with actual research and development and the total working hours.

R&D expenditure: the total amount of current cost and investment, from any kind of domestic or foreign source and irrespective of the fact whether the financial source was originally assigned for research, development or any other purposes.

R&D current costs are composed of labor cost and other current cost excluding the depreciation.

R&D capital expenditure is the annual gross expenditure on fixed assets used in R&D programs of units. The capital expenditure is composed of expenditure of land and building instruments and equipment and computer software.

2. INTERRELATION BETWEEN R&D EXPENDITURE OF THE COUNTRIES AND GDP

In the first step the computations were made using national-level data. First we have drafted the following hypothesis: There is a close correlation between the economical developments of countries and the intensity of scientific research: by the increment of per capita R&D expendi-

[2] In data collection, *Mrs. Csilla Obádovics*, PhD, associate professor of St. Stephen University helped us.

ture, the development level – measured by the per capita GDP – will increase. It has to be mentioned that recently a lot of complaints surged concerning the GDP index, and there are serious attempts to work out a more exact index. The main target is to work out a new index, which is able to take into consideration the welfare-challenges, the externalities originated from environmental effects, etc. However, in the examined period, the GDP is the officially accepted index, and for the time being, the statistical data and the long-term time series are based on this index.

We have made the following computation:

$y = f(x)$, where

$y =$ per capita GDP, €

$x =$ per capita R&+D expenditure, €

The summarizing statistics of the basic data used for this computation, are shown in the Table 1. It is to be seen from the data that the per capita GDP in the examined countries increased by 35.1 % from 2000 to 2008. At the same time, the increment of per capita R&D expenditure made out only 16%.

Table 1

The data of summarizing statistics of GDP and R&D

2000		
	Per capita GDP, €	Per capita R&D expenditure,€
Expected value	19 212.5	376.0
Standard error	2 318.7	63.4
Variance	13 116.6	358.9
Minimum	1 700.0	6.6
Maximum	50 200.0	1 212.2
Nr. of countries	32.0	32.0

2008		
	Per capita GDP, €	Per capita R&D expenditure,€
Expected value	25 966.7	436.5
Standard error	2 988.3	73.8
Variance	16 367.6	404.2
Minimum	4 400.0	18.2
Maximum	77 200.0	1 323.7
Nr.	30.0	30.0

Source: own calculations on the basis of Eurostat data.

The data of summarizing statistics are thought-provoking, because they show a restriction of possibilities of technical progress. The data of relative variance also contain important information.

	2000	2008
Per capita GDP	68%	63%
Per capita R&D	95%	93%

It is to be seen from the data that the differences both in per capita values of GDP and in R&D expenditure are extraordinarily big, and these differences have not practically changed during the last 8 years, better to say only very narrow signs show a certain leveling-off between the countries.

In course of our research work, we have applied linear, exponential and power types of functions. The closest correlation was obtained in case of power-function fitting. By means of fitting these functions, we examined the percentage values of mutual effects between factors. We wanted to learn that if there is 1% difference between the R&D expenditure of two countries, how high will be the difference in the per capita GDP levels.

The shape of power function for 2000 and the determination coefficient will be as follows:

$$\hat{y} = 672.2 \cdot x^{0.59}$$

$$R^2 = 0.94$$

It is apparent that there is a close positive correlation between the two factors. The value of correlation coefficient in 2000 was 0.9674, and that of determination coefficient was 0.9358, thus the intensity of R&D influenced the per capita GDP level by 94%. At the same time, it is also true that a 1% increment in R&D expenditure will increase the per capita GDP only by 0.94%.

The data for 2008 show similar tendencies.

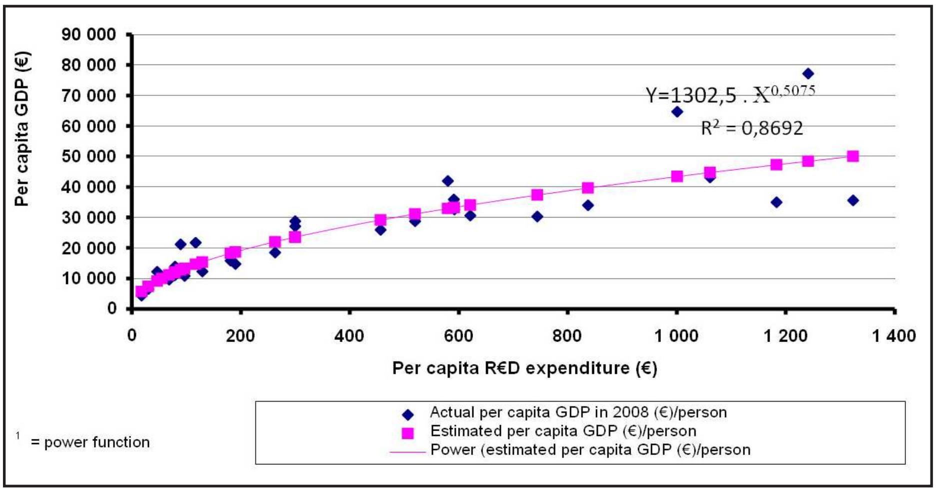
The obtained function is: $\hat{y} = 1302.5 \cdot x^{0.51}$

$$R^2 = 0.87$$

The main parameters of this equity in 2008 were almost identical with those of 2000, with the difference that 2008 was rather characterized by a shift toward an increasing differentiation. The degressive feature of increment is clearly shown by the graphics of power function fitted to the 2000 year data (Fig.1).

Figure 1

The development of per capita GDP (in €) in function of R&D



The degressive feature shows that the poorer a country is, the more important is the role of research and development in the improvement of economical situation of the given country. The returns to scale in countries with per capita R&D cost above thousand Euros seem to be random. From the point of view of economic decision-making, the comparatively big relative error of the regression straights cannot be neglected either.

3. EFFECT OF INTENSITY OF AGRICULTURAL RESEARCH AND DEVELOPMENT ON AGRICULTURAL GDP

Later we examined the importance of R&D intensity. The formerly used function fittings were made between the per capita agricultural GDP and the per capita R&D expenditure, or their per hectare values. We wanted to learn, if – according to our hypothesis – the interrelations, which we could demonstrate in case of national-level data, are valid also for the agricultural sector. The computations were made for 2000 and 2007 accordingly (unfortunately, the necessary data were not available for 2008). We could analyze the data of 25 countries in 2000 and those of 28 countries in 2007.

The characteristic regression data of per capita GDP (Y) and of per capita R&D expenditure (x) are shown in the Table 2.

Table 2

The characteristic regression data of per capita GDP (Y) and of per capita R&D expenditure (x)

2000		
	Per capita GDP, €	Per capita R&D cost, €
Expected value	1 072.589	15.332
Standard error	103.912	3.048
Variance	519.561	15.240
Minimum	337.475	1.870
Maximum	2 021.310	66.834
Nr. of countries	25	25

2008		
	Per capita GDP, €	Per capita R&D cost, €
Expected value	1 262.387	20.899
Standard error	167.780	5.254
Variance	887.809	20.804
Minimum	367.669	2.680
Maximum	4 991.264	137.260
Nr. of countries	28	28

Source: own computation

To the cumulative data, the following remarks are to be made:

The per capita agricultural GDP was EUR 1073 in 2000 and EUR 1262 accordingly, i.e. there was an increment by 17.6% during the examined eight years. At the same time, the per capita agricultural expenditure increased from the yearly EUR 15 to EUR 21, i.e. by 40%.

During the same period the staff of agricultural population decreased approximately by 30%. In the light of this reduction, the increment in R&D intensity can be considered much more moderate (taking into consideration that the increment in value of this index was partially due to the decline in staff).

Regarding to the per capita agricultural GDP, there are essential differences. The minimum per capita GDP was EUR 337 in 2000 and EUR 368 in 2008, while the maximum per capita GDP was EUR 2021 in 2000 and EUR 4991 in 2007. It can be seen that the extreme values, i.e. the differences, between countries increased.

The increment in differences is clearly shown by the values of relative variances.

– Relative variance of per capita GDP in 2000 = 48%, in 2007 = 70%.

– Relative variance of per capita R&D in 2000 = 99.3%, in 2007 = 129%.

In order to measure the effect of R&D intensity, the following computations were made:

– Quantification of the interrelation between the agricultural R&D expenditure per agricultural worker and the per capita agricultural GDP; and that of

– Interrelation between per hectare R&D expenditure and per hectare GDP.

The relation R&D expenditure per agricultural worker and the per capita agricultural GDP could be described in the best way by a power function in 2000 and by a linear function in 2007, accordingly.

The results of fitting of the power function are:

$$\hat{y} = 389.48 \cdot x^{0.392}$$

$$R^2 = 0.58$$

According to the data, this function type shows a strong correlation. The value of correlation coefficient is 0.75%, i.e. 1% of increment in R&D intensity generates 0.392% increment of GDP. The value of percentage effect is 58%. It is the degressive feature of increment in domestic production, which is specially interesting, and worth considering. According to the value of correlation coefficient, there is a medium-strong correlation between the per capita agricultural GDP and the value of per capita agricultural R&D. The strength of correlation is considerably influenced by the technical equipment of labor. The link between the productivity of live labor and instrumental efficiency is technical equipment of live labor, i.e. the quantity of assets per unit live-labor input.

In case of $\frac{D}{L}$ technical equipment (where D is the asset utilization, and L is the quantity of live labor), the resource employment of production is:

$\frac{D}{Q}$, where Q

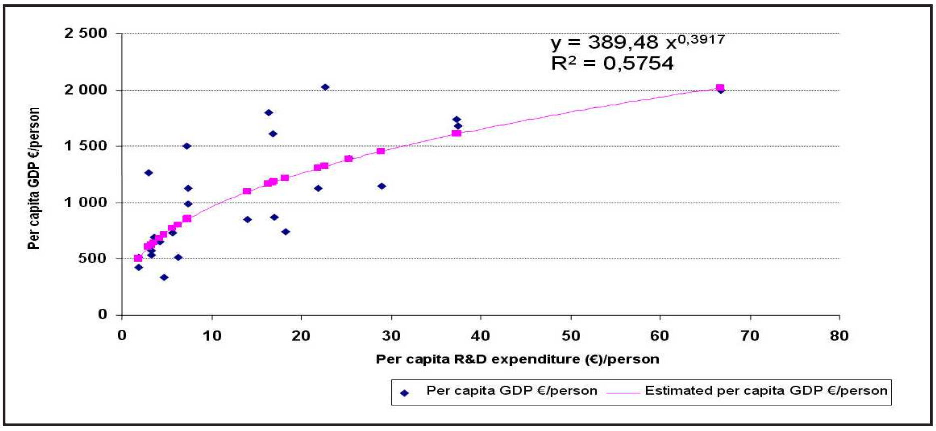
The $\frac{D}{Q}$ can be also expressed as the quotient of equipment and productivity indices:

$$\frac{D}{Q} = \frac{D}{L} \div \frac{Q}{L}$$

Namely, the development is basically a function of the output increment originating from the change in technical equipment of labor. There are two factors influencing the equipment level: the change in the stock of assets necessary to the substitution of unit quantity of live labor (substitution process), as well as the extension of assets' stock (expansion process). Generally the substitution can be interpreted on unchanged level, however the aim of productivity-increasing assets' investment – beside the substitution of live labor – is to reach a greater returns to scale. In the agriculture, these processes result in the increment not only of the average profit, but also of additional income, or of the ground rent, and after all in the increment of agricultural GDP. It can be seen from the graphics demonstrating this interrelation that in countries with lower R&D intensity, the picture is mixed, but the more intensive research and development show a clearer picture (Fig. 2).

Figure 2

The per capita GDP in power function of R&D expenditure in 2000



The obtained function in 2007:

$$\hat{y} = 371.01 \cdot x^{0.417}$$
$$R^2 = 0.51$$

In 2007 1 % increment in per capita agricultural R&D expenditure brought about 0.417% increment in the per capita agricultural GDP. It is also a degressive relation, which means that there was no essential change (step forward) in the characteristics of the relation in the last eight years.

The applied indices refer, first of all, the level of labor productivity, and it can be interpreted also in such a way, how labor productivity will be influenced by research and development in the agriculture of different countries. It is a very important indicator, because it is, on which the incomes of people living from agribusiness, the increment rate of these incomes and the possibility of technical development of different sectors depend. The calculated interrelations prove that research and development are one of the most decisive element of the growth in agricultural economy.

Setting out the data of Hungary, the following statements can be made:

The per capita agricultural GDP increased from EUR 728 in 2000 to EUR 1038 till 2007, i.e. by 43%. In the same period, the per capita agricultural R&D expenditure raised from EUR 5.7 to EUR 10.1, i.e. by 77%. It can seem that the R&D intensity in Hungary overpasses the average of other examined countries. Unfortunately, this process was provoked by the much greater extent of decrease in the agricultural employment. However, it is also true that "the staff remained in the sector" has theoretically better possibilities.

The "b" parameter of increment trend in per capita R&D is EUR 0.65. If the basic trend doesn't change, in 10 years the per capita agricultural R&D intensity can reach the level of EUR 16.6 (in comparison to 2007).

On the basis of these interrelations, the expected agricultural GDP per one agricultural employee can reach EUR 1143, i.e. – calculating with the actual exchange rate of HUF 270/EUR – the level of HUF 308 610.

Table 3

In the examination character the summarizing statistics of the features data

2000		
	GDP per 1 hectare agr. area, €	R&D cost per 1 hectare agr. area, €
Expected value	1 246.741	20.894
Standard error	303.247	6.012
Variance	1 174.471	23.286
Minimum	139.759	0.615
Maximum	4 852.860	88.322
Nr. of countries	15	15

2007		
	GDP per 1 hectare agr. area, €	R&D cost per 1 hectare agr. area, €
Expected value	1 262.387	20.899
Standard error	442.431	4.273
Variance	2 255.965	21.786
Minimum	266.816	1.574
Maximum	11 194.315	97.847
Nr. of countries	26	26

4. REGRESSION RELATIONS BETWEEN THE GDP (Y) AND THE R&D EXPENDITURE (X) PER ONE HECTARE AGRICULTURAL AREA

In international comparison, the performances of agricultural economies in different countries can be analyzed most frequently by means of per hectare input-output data. The indicators of area productivity express the level of economic management, and at the same time, the partial indicators facilitate to analyze and explore the structural differences (Table 3).

From the summarizing table of data it is clearly apparent that in the average of examined countries (in 2000 15 and in 2007 26 countries) the per hectare gross value added was EUR 1247 in 2000, and EUR 1514 in 2007, i.e. it increased by 21.4%. In the same two years, the per hectare R&D expenditure made out 20.89 and 18.73 EUR/ha, i.e. they didn't increased, but slightly decreased. However, the average data conceal the differences among individual countries. (In most countries, the R&D intensity increased, but in some countries – e.g. in the Netherlands – a drastic reduction can be observed, which draws back also the average.)

Behind the average data, the following extreme values occur:

	2000		2007	
	min.	max.	min.	max.
Per hectare agricult. GDP	139.76	4 852.86	266.82	11 194.32
Per hectare agricult. R&D	0.62	88.32	1.57	97.85

These data show clearly that in the examined period the minimum and maximum values also increased.

The effect of per hectare agriculture research and development expenditure on GDP can be approached in the best way by a linear function both in 2000 and 2007.

The summarizing regression parameters of the 2000 year calculation of linear function are as follows:

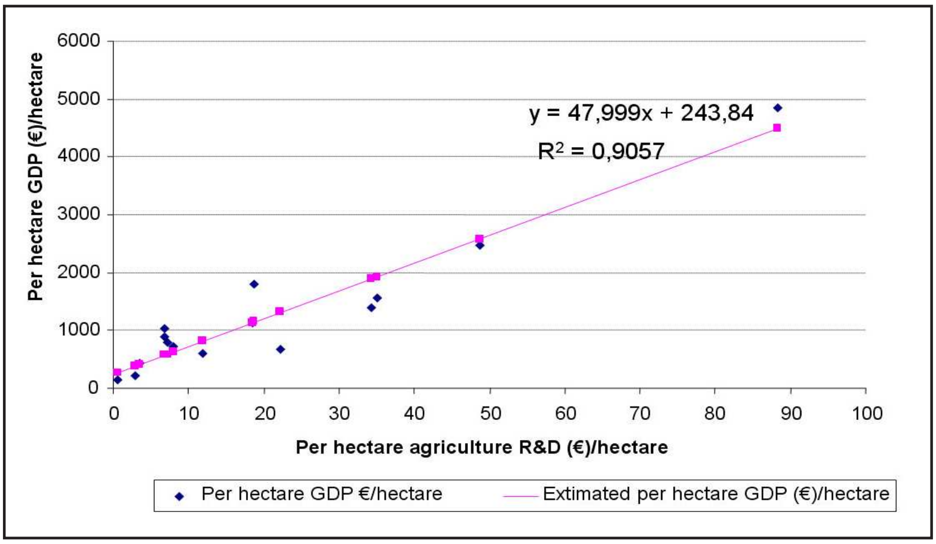
$$\hat{y} = 243.842 + 48.0x$$

$$R^2 = 0.91$$

According to our calculations, the research intensity measured by the per hectare agricultural R&D expenditure has an essentially greater effect on the development of agricultural GDP, than it has in case of per capita expenditure. Between these two factors there is a close correlation. The value of determination coefficient is 83%, thus the effect of R&D activity is obvious. According to the "b" parameter of linear regression straight the increment by EUR 1 in the per hectare R&D value will increase the amount of per hectare agricultural GDP by EUR 48 (Fig. 3).

Figure 3

The per hectare agriculture GDP in linear function of R&D expenditure in 2000



The most characteristic values of regression equity obtained from the 2000 year data of linear function are as follows:

The obtained function is:

$$\hat{y} = 35.06 + 79.0x$$

$$R^2 = 0.58$$

It can be seen well that although the tightness of the relation slightly decreased during 7 years, at the same time the quantitative effect of R&D intensified, because an increment by EUR 1 in the per hectare R&D expenditure increases the per hectare agricultural GDP by EUR 7.

Taking into consideration the data of Hungary, the value of regression equity (if x=3.45 €/ha) is 405.44 €/ha in 2000 and 482.40 €/ha in 2007, which is close to the effective value. Fig. 4 demonstrates the factors' relation, which clearly shows the character of interrelation between the two factors.

Thereafter we have examined, that within ten years how could the agricultural R&D in Hungary develop in itself and in comparison to other member states of EU, if the circumstances determining the above relations remain unchanged.

Let's suppose that Hungary within ten years will undertake agricultural R&D developments with different intensities (in comparison to the EUR 6.53/ha in 2007).

Increment rate	R&D cost €/ha	Agricultural GDP	
		€/ha	HUF/ha
1%	7.21	604.48	163 209
2%	7.96	663.72	179 207
3%	8.78	693.42	187 223
4%	9.67	798.77	215 668
5%	10.64	875.38	236 353

Calculating with exchange rate of HUF 272/EUR, in case of 5% increment in R&D cost (on constant prices), the Hungarian agricultural economy might double its per hectare GDP production, i.e. it will be able to improve the area productivity to such extent. (It involves all the elements of research and development, from soil cultivation till the improvement of harvesting technology, including also the modernization of business management and labor organization processes.)

5. THE WEIGHT OF R&D ACTIVITY IN THE AGRICULTURAL GDP FORMATION

In our further research work, we intend to quantify the participation of research and development activity in the development agricultural GDP.

The function of basic hypothesis is:

Y1: f(M,T,F,Xm),

The data used to the calculation are as follows:

Y1 = agricultural GDP in million €,
F = total agricultural area, thousand ha,
M = agricultural labor force, thousand head,
T = stock of agricultural assets, million €,
Xm = agricultural R&D expenditure, million €.

In 2000 we found 16 countries, where all the necessary data were at our disposal, in 2007 there were 26 such countries already.

In this relation, the statistical average values have smaller importance, since different countries appear in the examination in 2000 and in 2007. But the averages in themselves serve with relevant information, showing the participation of the agricultural area, of the agricultural staff, of the assets' stock, as well as of the R&D expenditure in the creation of agricultural GDP of different countries. The knowledge of these data is important, because the possible variant of the development of agricultural economies, the selection of possible technological variations, i.e. the support of economical decisions depend on them.

The summarized characteristics of the data used to the function computation for 2000 and 2007 are shown in the Table 4.

Table 4

The summarized characteristics of the data used to the function computation for 2000 and 2007

2000	Agric. GDP million €	Total agricult. area, 1000 ha	Agricult. labor force 1000 head	Agricult. assets' stock million €	Agric. R&D expenditure million €
Expected value	8 572.796	7 785.709	7 139.773	1 768.602	131.887
Variance	10 737.644	9 169.789	9 508.536	2 421.701	172.213
Minimum	154.004	137.600	180.600	47.154	1.720
Maximum	33 349.604	35 205.950	36 105.300	8 153.290	656.906
Nr. of countries	16	16	16	16	16

2007	Agricult. GDP million €	Total agricultural area, 1000 ha	Agricult. labor force 1000 head	Agricult. ssets' stock, million €	Agricult. R&D expenditure million €
Expected value	6 950.722	7 185.964	6 400.523	1 490.381	117.865
Variance	9 797.546	8 629.846	8 858.878	2 322.996	198.369
Minimum	130.750	11.680	155.500	9.114	0.771
Maximum	41 682.212	33 162.190	37 611.500	9 913.400	866.990
Nr of countries	26	26	26	26	26

Source: own calculations on the basis of Eurostat data

Regarding these data, the following remarks are to be made:

– In the agricultural production, the total agricultural area and the agricultural labor force decreased considerably (by 7.3 and 10.4% accordingly).

– The variance of agricultural R&D increased significantly (the value of relative variance was 131% in 2000 and 167% in 2007).

– In the data base of 2007, relatively more underdeveloped countries appear. It is the reason that the minimum assets' stock was EUR 47.2 million in 2000 and only EUR 9.1 million, and in totality the assets' stock decreased. The per hectare equipment level made out 227 €/ha in 2000, and 207 €/ha in 2007.

In spite of the changes in data base, it is possible for these two years to construct the production functions and to make the necessary calculations. In case of such types of computations, it is important to choose such equities, from which distribution ratio can be obtained. Such types are the linear, the exponential, or the Cobb-Douglas functions. In the agriculture – with regard to its peculiarities – generally the non-linear functions can play a more important role, since the relations have mostly not linear character.

The parameters of the Cobb-Douglas type function for 2000 are as follows:

The obtained function:

$$\hat{y} = 3.047 \cdot x_1^{0.163} \cdot x_2^{0.201} \cdot x_3^{0.518} x_4^{0.175}$$

$$R^2 = 0.97$$

$V\sigma_e$= 48.516%

According to the total correlation coefficient, the examined factors are in positive correlation with the agricultural GDP.

The results of Cobb-Douglas function shows the Table 5.

Table 5

The results of Cobb-Douglas function

Regressions statistics	
r value	0,974
r-square	0,949
corrected r-square	0,940
Standard error	0,363
Nr. of countries	26

Results of variance calculation:

	df	*SS*	*MS*	*F*	$V\sigma_e$	*F significance*
Regression	4	51,874	12,969	98,452		2.7E-13
Remainder	21	2,766	0,132			
Total	25	54,640			53,463	

	coefficients		Standard error	t-value	p-value	lower 95%	upper 95%
Axle section	Ln a	1,556	0,726	2,144	0,044	0,047	3,066
Total agricultural area,1000 ha	b_1	0,031	0,093	0,339	0,738	-0,161	0,224
Agric. labor force 1000 head	b_2	0,525	0,158	3,329	0,003	0,197	0,852
Agric. assets' stock, million €	b_3	0,198	0,177	1,118	0,276	-0,170	0,566
Agric. R&D expenditure, million €	b_4	0,210	0,150	1,399	0,177	-0,102	0,522
	A	4,741					

The obtained function is:

$$\hat{y} = 4.741 \cdot x_1^{0.031} \cdot x_2^{0.525} \cdot x_3^{0.198} x_4^{0.210}$$

$$R^2 = 0.95$$

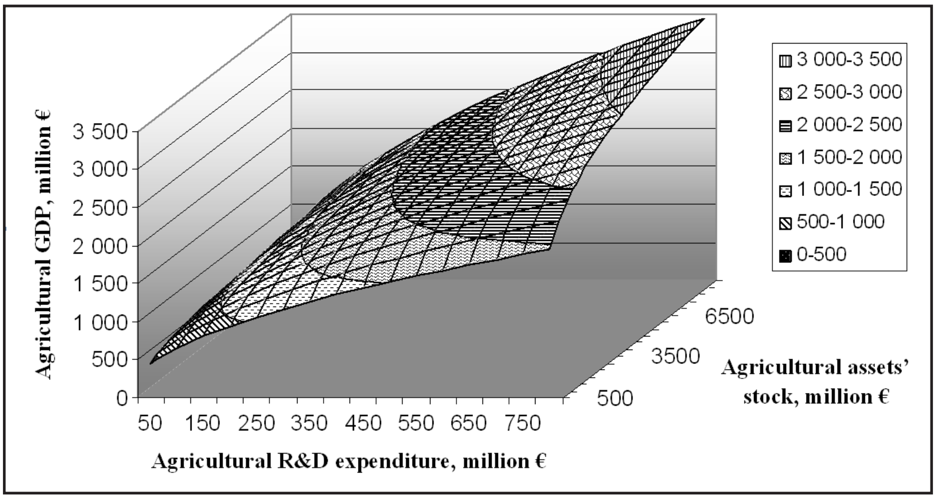
$V\sigma_e$= 53.463%

The tightness of relation and the fitting error are similar to those of 2000, however the role of some factors in the GDP creation has essentially changed.

For the sake of a better demonstration, herewith we present development of agricultural GDP, of agricultural R&D expenditure and of the assets' stock in a three-dimension graphics. The Fig. 4 clearly emphasizes the positive, but at the same time degressive feature of relations and the intervals of the changes.

Figure 4

The development of agricultural GDP in function of agricultural R&D expenditure and of agricultural assets' stock in 2007



After having made these computations, we demonstrate, how (expressed in percentage, to which extent the different production factors contribute to the development of GDP in case of C-D type relation (Table 6).

Table 6

The contribution of the examined production factors to the agricultural GDP

Type of the function and the year of basic data	Cobb-Douglas type function 2000	Cobb-Douglas type function 2007
Axle section*		
Total agricultural area,1000 ha	18.36	3.82
Agric. labor force 1000 head	22.39	62.76
Agric. assets' stock, million €	48.54	19.75
Agric. R&D expenditure, million €	10.71	13.67
	100.00	100.00

On the basis of these data, we make following statements:

• In 2000, in the creation of agricultural GDP, the assets' stock was the most important factor, and the labor-force staff, the available area and the R&D expenditure were on the second, third and forth places.

• In 2007 there was an essential rearrangement in the importance of factors: the agricultural labor force played a greater role in the creation of agricultural GDP. In this rearrangement it can be noticed that in the meantime the technical equipment of (live-)labor improved considerably, i.e. a greater knowledge accumulated in the labor force, therefore its role increased.

REFERENCES

(1) Csáki Cs. – Mészáros S. (ed.) (1981): Application of Operation Research. Methods in Agriculture. Mezőgazdasági Kiadó, www.avacongress.net/ava2005/presentations/plenary_II/4.pdf, 1534. p. – (2) Nagy J. (ed.) (2009): The Agricultural R+D+I strategy. Manuscript. Saint Stephen University – (3) Schofield, W. (1996): Survey sampling. (In: Sapsford, R. – Jupp, V. (eds.): Data Collection and Analysis. London, Sage Publications and the Open University Press – (4) EUROSTAT data. 2000-2008. – (5) http://biotechnologia.lap.hu/ – (6) Szűcs I. – Fekete F. M. (2008): Efficiency in Agriculture. Agroinform Publisher, Budapest, 205. p. – (7) Szűcs I. – Mohamaed Zs. – Takács Sz. (2010): Situation of Agricultural Research and the Most Important Tasks. Gazdálkodás. 54. year. Nr. 1. 71-80. pp. – (8) Pfeffermann, D. – Barnard, C.H. (1991): Some New Estimators for Small-Area Means With Application to the Assessment of Farmlend Values. Journal of Business and Economic Statistics. January, Vol. 9. No.1 – (9) Thirtle et al. (2008): Modeling the Length and Shape of the R&D Lag: an Application to UK agricultural productivity. Agricultural Economics, July, 73-85. pp. – (10) Török Á. – Petz R.: An Attempt to Examine Interrelations between R&D Intensity and Export Structure in the Hungarian Economy. Közgazdasági Szemle, XLVI. year, March, 213-230. pp.

ADDRESS:

Dr. Szűcs István, egyetemi tanár, intézetigazgató, Szent István Egyetem Gazdaság- és Társadalomtudományi Kar, Gazdaságelemzési Módszertani Intézet, Gödöllő
professor, head of department, Szent István University, Faculty of Economics and Social Sciences, Institute for Economyc Analysis and Methodology
2103 Gödöllő, Páter Károly u. 1., Tel.: +36-28-522-000, Fax: +36-28-410804, E-mail: Szucs.Istvan@gtk.szie.hu

Takács Szabolcs, kirendeltségvezető, Szabolcs-Szatmár-Bereg Megyei MVH Kirendeltség, Nyíregyháza
head of branch office, Branch Office of Agricultural and Rural Development Agency in Szabolcs-Szatmár-Bereg County
4401 Nyíregyháza, Pf. 422, Tel.: +36-42-814-932, E-mail: takacs.szabolcs@mvh.gov.hu

Mohamed Zsuzsanna, PhD hallgató, Szent István Egyetem, Gazdaság- és Társadalomtudományi Kar, Gazdaságelemzési Módszertani Intézet, Gödöllő
PhD student, Szent Istvan University, Faculty of Economics and Social Sciences, Institute for Economyc Analysis and Methodology
2103 Gödöllő, Páter Károly u. 1., Tel.: +36-20-9364-021, E-mail: m.suzan10@freemail.hu

Bedéné Szőke Éva, egyetemi adjunktus, Szent István Egyetem, Gazdaság- és Társadalomtudományi Kar, Gazdaságelemzési Módszertani Intézet
assistant professor, Szent István University, Faculty of Economics and Social Sciences, Institute for Economyc Analysis and Methodology
2103 Gödöllő, Páter Károly u. 1., Tel.: +36-28-522-000, Fax: +36-28-410-804, E-mail: Bedene.Szoke.Eva@gtk.szie.hu