**Szent István University**
**Gödöllő**
**PhD School of Management and Business Administration**

**Theses of Doctoral (PhD) Dissertation**

# MEASURING THE EFFECT OF AGRICULTURAL TECHNICAL DEVELOPMENT AND RESEARCH

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# 1. INTRODUCTION

## 1.1. Topicality of the item

**In my thesis I have analyzed the effect of research and development (R+D) activity on the development of economy. My intention has been to demonstrate that the emphasized preference of research and development has decisive importance from the point of view of the competitiveness of a country or of a product. Making use of growth reserves in Hungarian agriculture can greatly contribute to the improvement of living standards and the preservation and retention of rural population, as well as to the safety of food provision and to the increment of foreign trade income.**

The research and development are expensive activities, the expenses of which are financed partly by the state and partly by those companies, who expect considerable returns from the research results. Therefore it is important to measure how the expenses would be repaid, if they will yield the expected results and if it is worth making further efforts to increase the R+D intensity.

**The main objective of my research work, or my PhD thesis is to display the present situation of agricultural research in Hungary, outlining the peculiarities of this research, and at the same time to draw a picture of the possible, quantifiable role the agricultural research on national and international levels can play in the growth of GDP.**

In the first step of the research work, I have made a comprehensive survey of Hungarian and international literature. On this basis I have compiled my research hypotheses and the methodological procedure that is necessary to justify the hypotheses, and after then the sufficiently deep information background. The main difficulty has been in the compilation of data base, since the official Hungarian statistical data, but also those available on international level are quite aggregate and are not convenient to make profound analyses.

## 1.2. Research hypotheses and the applied methodology

**The basic idea of my research work has been that the intensity of research and development activity and the extent of expenses spent for this activity, greatly influence the economic, and on closer examination, the agricultural development. During my examinations, I have started from three hypotheses, as follows:**

**$H_1$ hypothesis**:

- ***There is a close correlation between the economic development of a certain country and the intensity of scientific research and development in the given country. Thus, the higher developed a country, the more it will spend on the development and application of scientific results.***

**$H_2$ hypothesis:**

- ***In the agriculture, beside the three main factors (labor, capital, land) it is the intensity of research activity that considerably contributes to the growth of agricultural GDP.***

**$H_3$ hypothesis:**

- ***In the agricultural production, the biotechnological results have prominent importance among the new scientific results. I suppose that there is a statistically justifiable connection between agricultural results and the extent of expenditure spent on biotechnological research.***

**I try to justify my hypotheses – beside of secondary research (i.e. evaluation of results published in related Hungarian and international literature) – by primary research and statistical computations.**

I have examined the first hypothesis by regression analysis:

- the relation between the per capita GDP and the economic development of a country. I have analyzed the interrelation between the below outlined factors:

$$y = f(x_1)$$

where

$y$ = the per capita GDP, in €

$x_1$ = the per R+D expenditure, in €;

To justify the other hypotheses I have established functions in a similar way.

I have extended the calculations to the EU member states, in some cases drawing into the analysis other countries as well.

To display tendencies, as well as to calculate the pace and extent of changes I have made use of the possibilities of analytical trend computation.

The arsenal of regression analysis has meant a methodological support. I have computed bivariate and multivariate functions of different type, and applied modified Cobb-Douglas functions in case of multivariate factor-analysis.

# 2. PROCESSING THE LITERATURE

While processing the literature I intended to arrange it according to my research objectives.

## 2.1. Research, technical development and economic growth

Mr. Imre Dimény formulated the conditions of agricultural development from own reserves, the basic purpose of technical development, the improvement of competitiveness in his essay entitled: „Considerations of agricultural policy and the technical development (Dimény I., 1986). According to the wording of Mr. Dénes Lakatos „The basis of technical development is the scientific-technical revolution. The conditions of scientific foundation of technical development are created in the research, and after that the work of practical extension of scientific results can be started." (Lakatos D., 1990.). The permanent technical-economical innovation is the motor of economic growth, and the precondition to this innovation is a high-level basic and applied research. „*It is a compound process, whose definite aim is to come into market with a certain novelty or original idea – generally in form of a successful product or of a procedure" /Husti, István, 2008./*

**Aims of technical development:**

- to increase labor productivity (reduction of cost of production).
- to increase yields.
- to improve labor conditions.
- to meet the consumers' demands on highest possible level.
- to widen assortment.
- to improve the quality.

The question of concept and target system of technical development, as well as the definition of up-to-datedness stands in the foreground of professional disputes also in Hungary. Thus, **the state of technical development is an economic category**. According to **Fenyvesi, László,** "It is also important that in the field of agricultural researches, the basic research has to be – to a certain extent – also part of the production process (…), i.e. a successful, "marketable" product, method, result should be created". /Fenyvesi L.,2008/.

According to the wording of **Dougherty, D:** "The innovation means the creation of the concept of a new product or of a new service, their development and product development, their production, marketing and continuous managing". **Dougherty, D. (1996)**

The established set of requirements of development also demands a complex approach. „In the spirit of sustainable development, we will succeed in creating a concordance among the material requirement of society, the population growth and the utilization of natural resources, minimizing at the same time minimizing the environmental pollution". (W.W. Nerona and Company, New York, 1981.) According to Mr. István Láng and Mr. László Csete, "…in this process, the scientific-technical progress has a decisive importance (…) in all fields of national economy" (Láng István-Csete László, 1996).

In the procession of literature, the innovation strategy of OECD has to be emphasized. The activity connected to the science and technology, is coordinated by the Directorate for Science, Technology and Industry. The Committee has made a country-study on the innovation system in Hungary. (OECD Reviews of Innovation Policy – Hungary, 2008.)

„***The agricultural economy – in case of a convenient R+D activity – preserves genetic resources of soil, of living waters, as well as of vegetable and animal kingdoms, prevents from the degradation of human environment, and results in a development, which is efficient from technologic, and acceptable from social point of view.”*** (*FAO, Food and Agriculture Organization of UNO*: Challenges for the XXI. century. Documents of UNO Conference on Environment and Development: Budapest, 1993.)

The conceptions of sustainable agricultural development have to become integral parts of the prevailing agricultural policy (LÁNG-CSETE, 1996). In case of awards of financial supports, also the requirements of sustainable development are to be taken into consideration (LÁNG et al., 1995) the sustainable agriculture in the XXI. century doesn't require any return to the technologies of past centuries, but the application of newest scientific and technical achievements. It can be reached only by highly developed infrastructure and by radical increments of preparedness of the staff, working in agriculture.

## 2.2. Measuring the performance of R+D activity

„Evaluating the effects of technical development – and within it of technical development supports – it is possible:

- to measure
  - the economic performance obtainable by means of supports
- to calculate
  - the economic returns by means of indices of return, which – according to the aspect of evaluation – can be:
    - production return (return of investment value without supports), which examines the return of own sources of farmers, disregarding to the fact that supports will constitute hereinafter part of his property;
    - returns on national economy level (return of investment value increased by supports), which examines the joint return of farmer's investment and of social transfer;
- however, it is not possible to measure the below mentioned effects, which are only to be estimated:
  - social effects
  - complementary income, received by means of created public goods (environmental effects, infrastructure, etc.).

The basis of evaluation of different technologies is the contribution fund, which can be defined by a mathematical formula. [Nagy 1987; Takácsné György Katalin, 1989]. According to the opinion of several authors, the convenient indicator numbers – together with the measurement of their changes – are suitable to substantiate the selection of optimum decision among the technological variations. [Wiles, 2004].

Among the elements determining the economic development – according to Szűcs – it is the intensity of R+D expenditure, which has to be emphasized.

**THE COMMISSION OF EUROPEAN COMMUNITIES published a communiqué under the title „Science, Technology, the Key of European Future", dealing with the main**

**principles of future research-supporting policy of the EU.** The most important messages of this communiqué are as follows:

- One precondition to the increment of scientific performance is "the appearance of European 'knowledge-centers'".
- The European Union supports the research in the member states. It is necessary to rationalize and rearrange these activities in such a way that they could create an integral whole of critical mass.
- This Europe has to be made attractive for the best researchers, validating the principle of "one profession – several carriers".

## 2.3. Measuring the effect of R+D activity on the basis of partial efficiency

In order to understand the importance of scientific-technical progress, first of all we have to resolve the quantification of its effects and to establish the suitable methodology. To measure the efficiency of basis and applied researches, there are various methods, proposed by the scientology (publication numbers, citation indices, etc.). However, measuring of the effect of technical progress incorporated (embodied) into production process requires the application of more complicated mathematic-statistical methods. The separation of factor returns can be generally resolved by production functions of Cobb-Douglas type (in case of existence of certain condition-system).

From the point of view of scientific-technical progress, the classical production functions are to be fined down. If the classic „labor-capital-land" factor effect will be described by the function

y = f (M, T, F), then the production function, taking into consideration also the technical progress, can be defined in the following way (SZŰCS I., 1999):

$y_k = f(M, T, F, H, t)$

where: y = profit
M = labor content
T = capital tie-up
F = land
H = ratio of R+D expenditure to the whole GDP in the branch
t = average time requirement for the introduction of new scientific results (month, year)

During my research work, I have transformed this function, and by its means tried to justify my hypotheses.

# 4. CONTROL OF THE RESEARCH HYPOTHESES

To the justification of my hypotheses, I have made use of the below mentioned data bases:

- Publications of the Hungarian Central Statistical Office between 1997 and 2008 on research and development, particularly on R+D costs and expenditure, on the number of R+D places, on research staff, on R+D investments and on the research potential of universities.
- Primary statistical data published by EUROSTAT between 2000 and 2008 and information derivable from these data. My research and analytical work has been concretely built on the following data:

In the data basis there are various data appearing, i.e. those, by whose means I can justify the hypotheses, or those, which are to be rejected.

Countries drawn into examination have been: averages of EU-15 and of EU-25, and separately 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.

## 4.1. Interrelation between the state of development and R+D intensity

Justification of $H_1$ hypothesis:

- There is a close correlation between the economic development of a certain country and the intensity of scientific research and development in the given country. Thus, the higher developed a country, the more it will spend on the development and application of scientific results.

In order to justify this hypothesis, we have made the following calculation:

$y = f(x)$, where
$y =$ per capita GDP in €
$x =$ per capita R+D expenditure in €

I have established the bivariate function, between the development of per capita R+D expenditure and of GDP, separately on the basis of the years 2000 and 2008 in order to be able to examine, if the values of these parameters, describing the above relations have changed during an almost ten-year time-span.

The obtained function is: (2000):

$$\hat{y} = 6583{,}301 + 33{,}59x$$
$$R^2 = 0{,}84$$

The other obtained function is: (2008):

$$\hat{y} = 11025{,}2 + 34{,}2x$$
$$R^2 = 0{,}71$$

According to the results of variance-analysis, The F value shows a significant correlation. The $R^2$ value, showing the effect of independent variable is equal to 0,84, i.e. the R+D values have a considerable influence in the development of GDP. According to „b" parameter of linear regression equation, a per capita increment of 1 euro in R+D intensity generates a per capita increment of 33,60 euro in GDP.

Computations made with the data for 2008 show a roughly similar tendency. So, we can lay down that there is still a strong relation between the R+D intensity and GDP. The main difference between the data for 2000 and 2008 and the correlations is that the level had been rising, and larger per capita GDP level belongs to the same amount of R+D expenditure. All these are proven by statistical data and by the results of variance analysis.

## 4.2. The effect of agricultural research and development

Thereafter I have examined the importance of R+D intensity in agricultural industry. The formerly used function-fittings have been made between the per capita agricultural GDP and the per capita R+D expenditure, or between their per hectare values.

According to my first hypothesis I have made the following computations:

- 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 computations were made by means of application of regression analysis in the so-called Analysis ToolPak of Excel extension program.

The below outlined data show the results of linear function's computation for 2000:

The obtained function is:

$$\hat{y} = 698{,}5 + 24{,}414x$$
$$R^2 = 0{,}513$$

According to the correlation coefficient, there is a medium-good correlation between the values of per capita agricultural GDP and the per capita agricultural R+D expenditure. In this case, the strength of correlation is influenced also by the technical equipment of labor, which can substitute the lower level of live labor.

The obtained function is:

$$\hat{y} = 681{,}9 + 27{,}78x$$
$$R^2 = 0{,}757$$

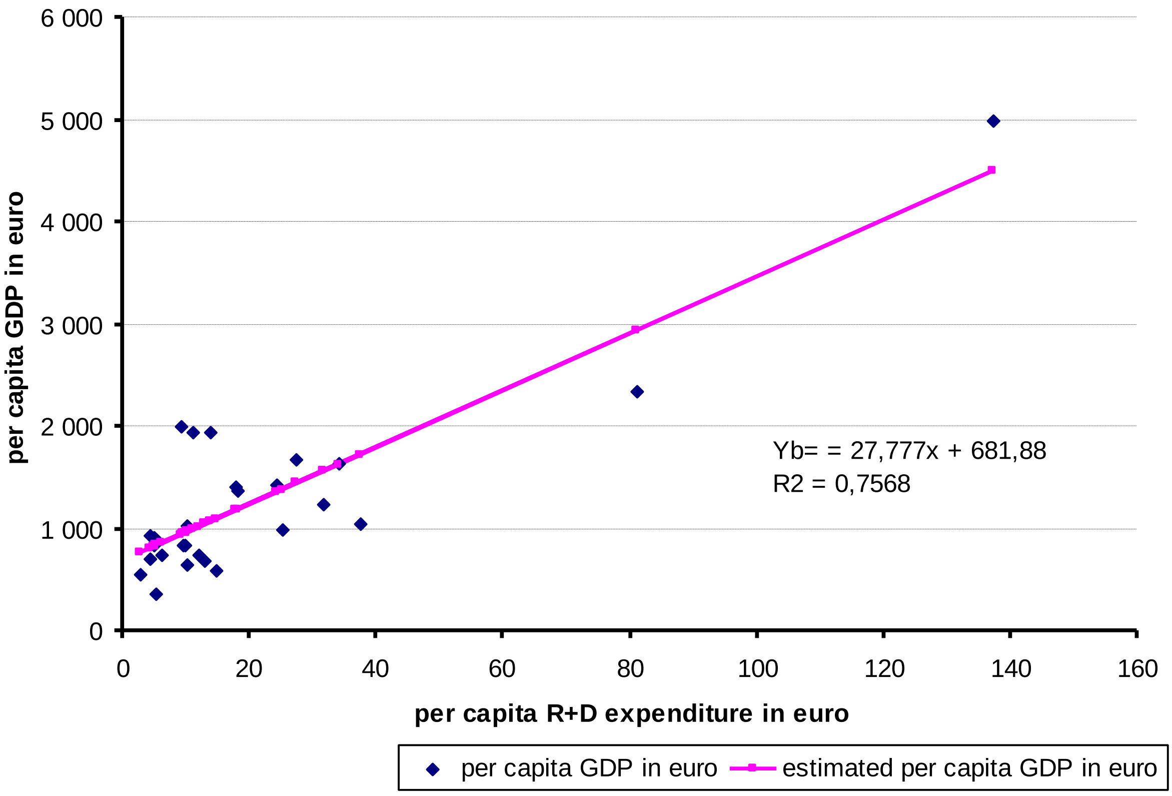



***Figure 1. The per capita GDP in linear function of per capita R+D expenditure in 2007***

Source: Own calculation

According to the data for 2007, 1 euro increment in research and development expenditure yields EUR 27,78 increment in agricultural GDP on a much more reliable probability level.

I have checked the relation between the two factors also by means of an e**xponential function.** I have checked that one euro increment of R+D expenditure by how many per cent will increase the per capita agricultural GDP.

As for the data related to Hungary, I can lay down the following statements:

The per capita agriculture GDP rose from the level of EUR 728 in 2000 to EUR 1038 in 2007. The increment is equal to 43 %. In the same period, the per capita agricultural R+D expenditure rose from the level of EUR 5,7 to EUR 10,1. This increment is equal to 77 %. It may seem that the R+D intensity in Hungary exceeds the average of examined countries. Unfortunately, the reason for this phenomenon is the much larger reduction of the number of agricultural employees in Hungary. However, it is also true that those who remained in the agriculture have better potential possibilities.

The “b” parameter of increment trend of per capita R+D is equal to 0,65. If the basic trend will not be changed, then after 10 years the intensity of per capita agricultural R+D may reach the level of EUR 16,60.

On the basis of the regression equation Y = 681,9 + 27,78x, the probable agricultural GDP per 1 agricultural employee can reach the EUR 1143, i.e. – calculating with the actual currency rate of 1 EUR = 270 HUF – the EUR 308 610 level.

**Regression relation between the per hectare GDP (Y) and per hectare R+D expenditure (x)**

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

From the summarizing 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. these numbers didn’t increased. 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 the average, too.)

**Results of computation of exponential function for 2000**

The obtained function is:

$$\hat{y} = 457{,}7 \cdot 1{,}032^{x}$$
$$R^2 = 0{,}65$$

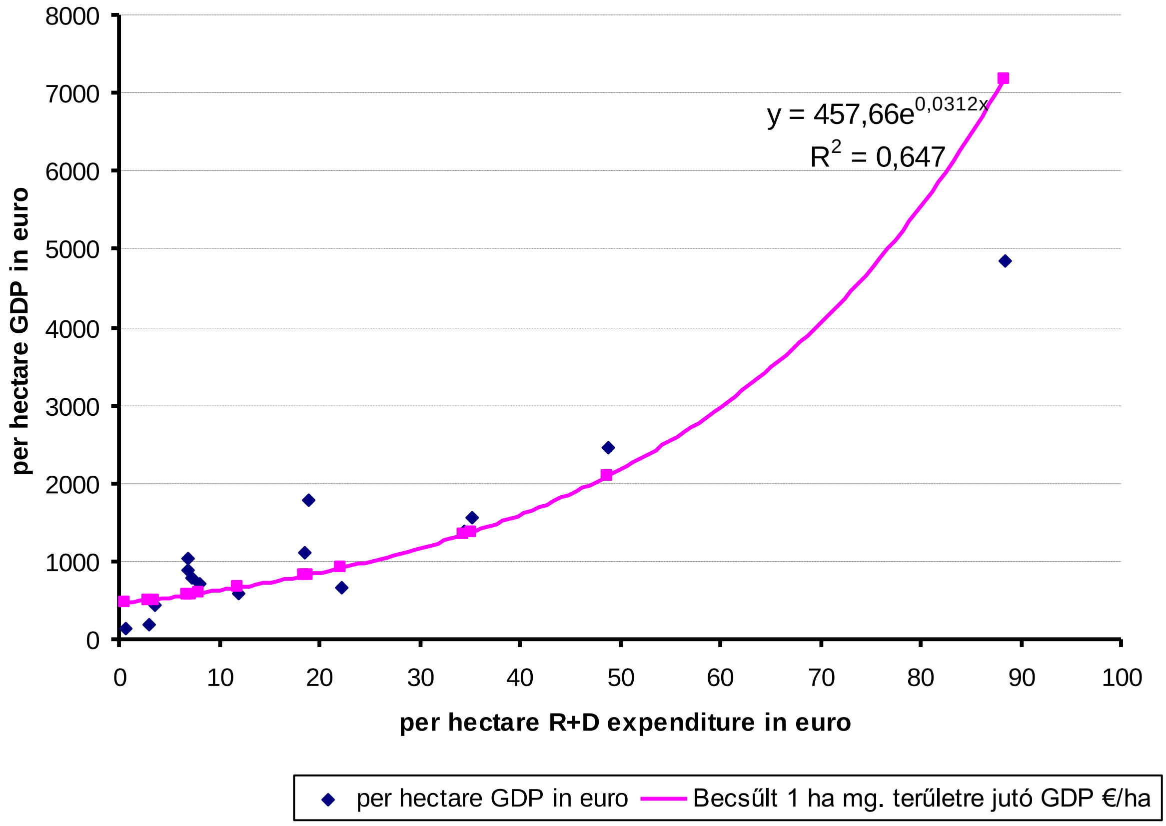



***Figure 2. Per hectare GDP in exponential function of R+D expenditure in 2000***

Source: Own calculation

The „b" parameter of the function shows that 1 euro increment in per-hectare value of R+D expenditure will increase the per-hectare GDP value by 3,2 %.

This relation was similar also in 2007. The most important indicators:

**Results of the exponential function for 2007**

The obtained function is:

$$\hat{y} = 528{,}5 \cdot 1{,}031^{x}$$
$$R^2 = 0{,}63$$

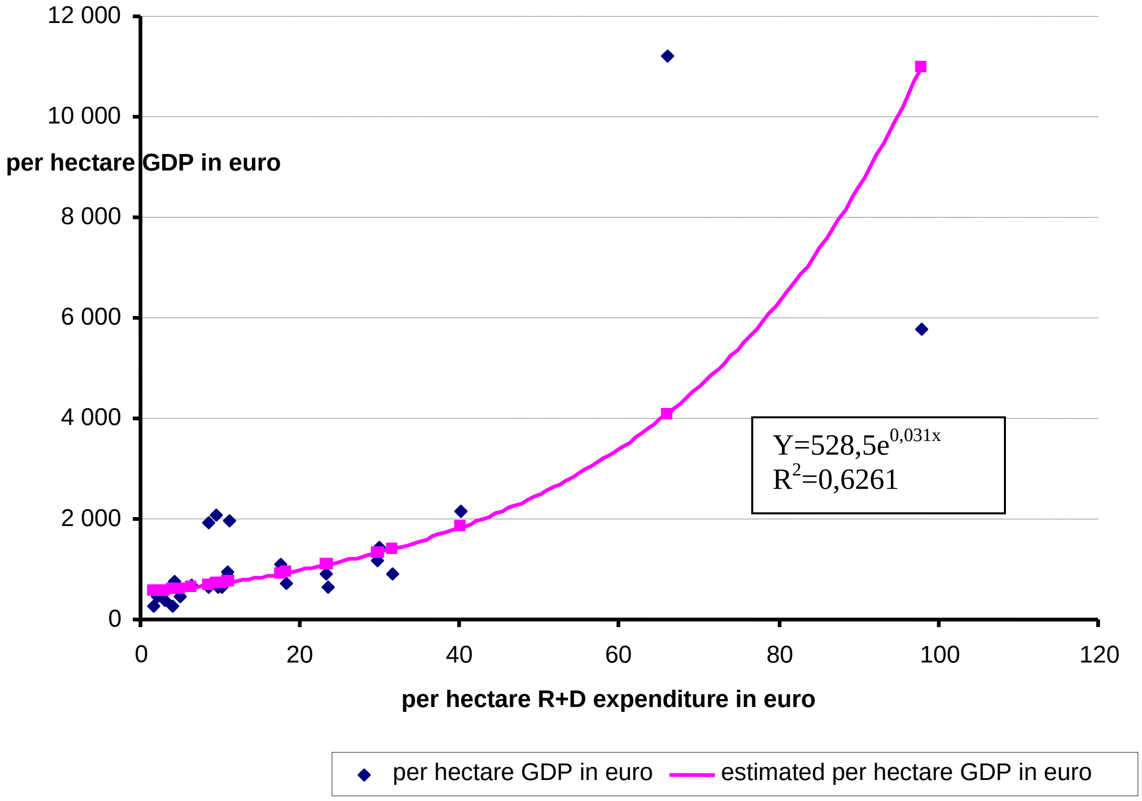



***Figure 3. Per hectare GDP in exponential function of R+D expenditure in 2007***

Source: Own calculation

Another type of information can be obtained from the relation between the two factors by a power function, which shows by how many percent does the per capita agricultural GDP increase in the case of a one euro increment of R+D expenditure.

## 4.3 I have tested the control of the 2nd hypothesis by fitting of multivariate production functions

When formulating this hypothesis, my starting point has been that the intensity of agricultural R+D activity plays an intensive role in the development of agriculture.

During my further research work, I have demonstrated the weight of research and development activity in the development of agricultural GDP.

The function of the basic hypothesis is:

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

The data used for the computation are as follows:

- agricultural GDP in million €
- total agricultural area in thousand hectares

– agricultural labor force (staff) in thousand men
– total value of fixed assets in million €;
– agricultural GDP expenditure in million €;
– in 2000 we found 16 countries, where all the necessary data were at our disposal, in 2007 there were 26 such countries already.

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.

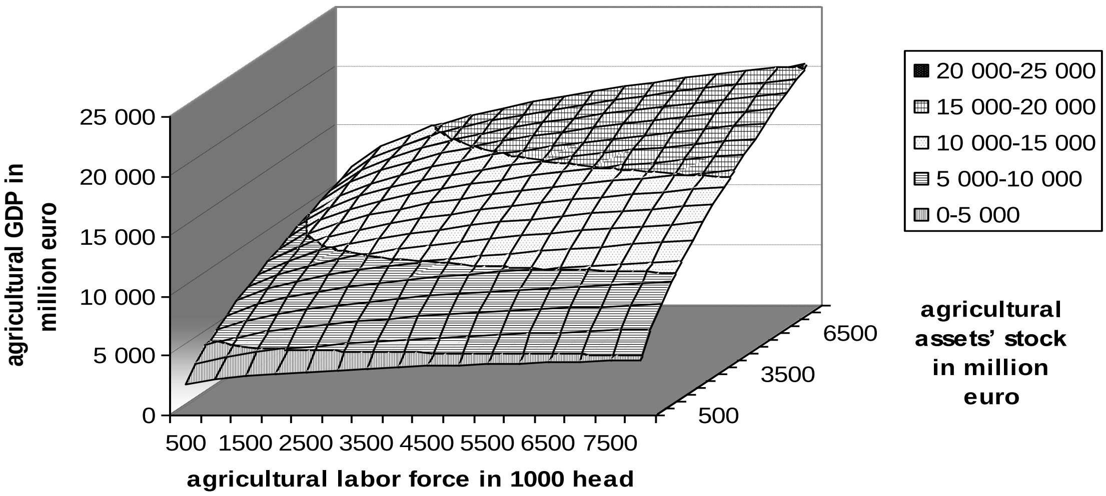
In spite of the changes in the data base, it is possible for these two years to construct the production functions and to make the necessary calculations for hypothesis 2 separately. In the theses I give forth only the results of C-D type functions.

The obtained function is: $\hat{y} = 3{,}047 \cdot x_1^{0{,}163} \cdot x_2^{0{,}201} \cdot x_3^{0{,}518} x_4^{0{,}175}$

$R^2 = 0{,}97$

$V\sigma_e = 48{,}516$ %

We can see that in case of a strong correlation coefficient, each factor has a positive relation to the agricultural GDP. This fact is well demonstrated also by the following figures.




* calculating w ith average values of agricultural R+D expenditure and of agricultural area

***Figure 4. Development of agricultural GDP in function of agricultural labor force and of agricultural assets' stock in 2000***

Source: Own calculation

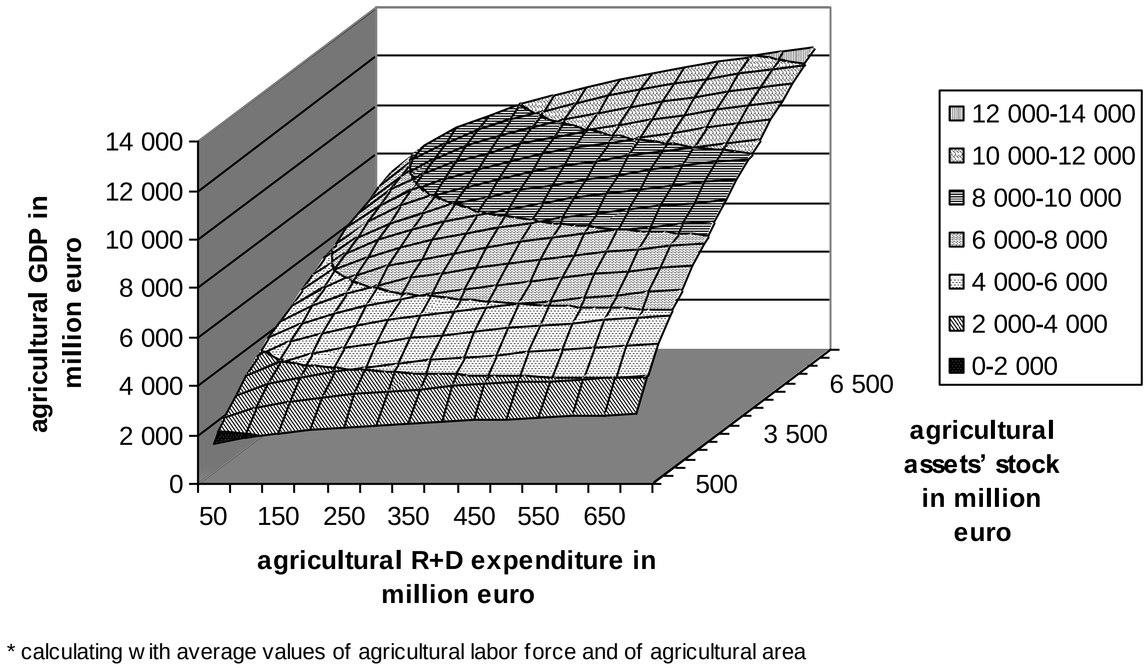



***Figure 5. Development of agricultural GDP in function of agricultural*** R&D ***expenditure and of agricultural assets' stock in 2000***

Source: Own calculation

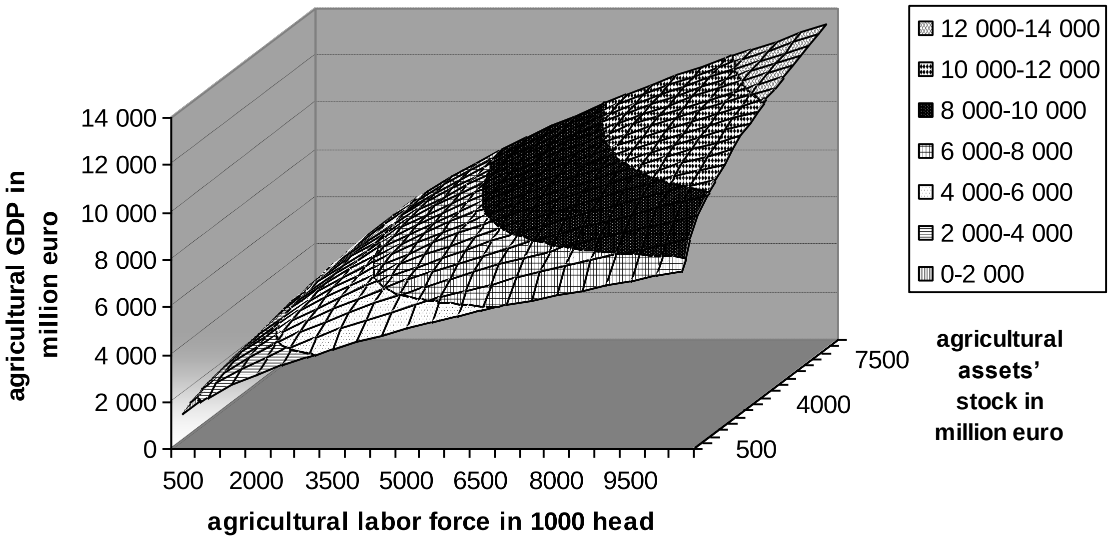
**Results of the Cobb-Douglas type function for 2007**

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 %

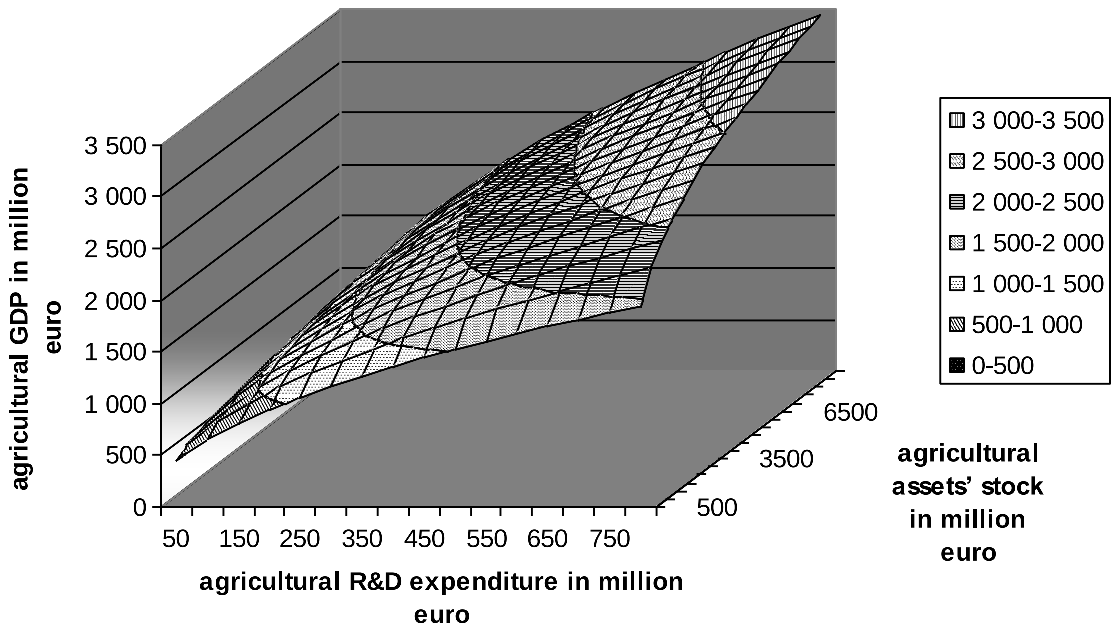
The tightness of relation and the fitting error in 2007 are similar to those of 2000, however the role of some factors in the GDP creation has essentially changed.




* calculating w ith average values of agricultural R+D expenditure and of agricultural

*Figure 6. Development of agricultural GDP in function of agricultural labor force and of agricultural assets' stock in 2007*

Source: Own calculation




* calculating w ith average values of agricultural labor force and of agricultural area

*Figure 7. Development of agricultural GDP in function of agricultural* R&D *expenditure and of agricultural assets' stock in 2007*

Source: Own calculation

After having made these computations, I demonstrate how (expressed in percentage), to which extent the different production factors may contribute to the development of GDP.

**3. COBB-DOUGLAS TYPE FUNCTION 2000**

| DENOMINATION | Coefficients | Logarithms of averages | Computed value | | % | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3=1*2** | **4** | **5** | **6** |
| | | | **a** | **b** | **A** | **b** |
| Axle section* | 3,047 | | 3,05 | | 27,65 | |
| Total agricultural area,1000 ha | 0,163 | 8,960 | 1,46 | 1,46 | 13,28 | 18,36 |
| Agric. labor force 1000 head | 0,201 | 8,873 | 1,79 | 1,79 | 16,20 | 22,39 |
| Agric. assets' stock, million € | 0,518 | 7,478 | 3,87 | 3,87 | 35,12 | 48,54 |
| Agric. R&D expenditure, million € | 0,175 | 4,882 | 0,85 | 0,85 | 7,75 | 10,71 |
| Agricultural GDP | | 9,056 | 11,02 | 7,97 | 100 | 100 |

Source: Own calculation

**4. COBB-DOUGLAS TYIPE FUNCTION 2007**

| DENOMINATION | Coefficients | Logarithms of averages | Computed value | | % | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3=1*2** | **4** | **5** | **6** |
| | | | **a** | **b** | **A** | **b** |
| Axle section* | 4,741 | | 4,74 | | 39,29 | |
| Total agricultural area,1000 ha | 0,031 | 8,880 | 0,28 | 0,28 | 2,32 | 3,82 |
| Agric. labor force 1000 head | 0,525 | 8,764 | 4,60 | 4,60 | 38,10 | 62,76 |
| Agric. assets' stock, million € | 0,198 | 7,307 | 1,45 | 1,45 | 11,99 | 19,75 |
| Agric. R&D expenditure, million € | 0,210 | 4,770 | 1,00 | 1,00 | 8,30 | 13,67 |
| Agricultural GDP | | 8,847 | 12,06 | 7,32 | 100 | 100 |

Source: Own calculation

* Effects of other, among independent variables disregarded factors.
Computed value „a"= effects of other factors taken into consideration.
Computed value „b"= effects of other factors disregarded, axle section = 0

By means of these parameters, I have computed how, i.e. in what proportion these factors may contribute to the value of agricultural GDP.

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

- From economic point of view, the C-D type functions are well applicable to measure the approximate effect of production factors analyzed by us (however the negative factor returns can hardly be interpreted).

- In 2000, it was the agricultural assets, and in 2007 the labor, which had a greater contribution to the agricultural GDP. This change shows that in the meantime, the degree of technical supply in live labor has considerably improved, i.e. a greater knowledge has accumulated in the labor force, the role of which has upgraded among production factors.
- 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.

By the above explications, I consider my second hypothesis to be justified, i.e. the agricultural R+D expenditure contribute to a significant and – regarding to its percentage weight – important extent to the creation of gross agricultural product.

## 4.4. Testing my research hypotheses

Before having started with my research work, I have supposed that the agricultural biotechnological research had an emphasized role in the development of agricultural industry.

According to the 3rd hypothesis, I have examined how the application of biotechnology may influence in the performance of agriculture. During this examination, I have been looking for the correlation between the number of per-hectare agricultural patents and the agricultural GDP in EU member states, better to say, I have computed the regression equity describing the relation between these two factors.

As formerly, I have computed 3 types of functions, namely the linear, exponential and power functions. To the basic data relating to the fitting of estimation functions, the following remarks are to be made:

**a)** In the average of EU member states, the per-hectare embodied R+D invention was equal to 20 patents in 2000. However the situation was characterized by big diversity. There was a country where one single patent fell to 3 hectares (Lithuania), and there was another country where the per-hectare number of patents was almost 100 (the Netherlands). In 2007 the intensity of R+D activity measured by the patents' number decreased, and there was a significant rearrangement between the countries.

**b)** Hungary belongs to the countries which use few patents: in 2000 the per hectare number of patents was not more than 1,6, but in 2007 it increased to 5,4 already, i.e. a relative dynamic change was carried out. All these events are raising hopes, because – as we can see later – the R+D results embodied in patents and their application in practice have a considerable effect on the development of agricultural GDP.

**Table 32.**

**Overall data on the developments of agricultural, biotechnological patents and the agricultural GDP**

| | ***Per hectare number of biotechnological patens, 1000 db/ha*** | ***per hectare GDP €*** | | ***Per hectare number of biotechnological patens, 1000 db/ha*** | ***per hectare GDP €*** |
|---|---|---|---|---|---|
| **2000** | | | **2007** | | |
| Expected value | 19,737 | 1225,986 | Expected value | 17,067 | 1485,61 |
| Standard error | 7,030 | 249,831 | Standard error | 5,702 | 426,34 |
| Variance | 30,645 | 1088,988 | Variance | 29,630 | 2215,33 |
| Minimum | 0,314 | 139,759 | Minimum | 0,065 | 266,82 |
| Maximum | 99,932 | 4852,860 | Maximum | 106,369 | 11194,32 |
| Nr. of countries | 19 | 19 | Nr. of countries | 27 | 27 |

*Source*: own calculations

As for the relation between the per-hectare number of agricultural, biotechnological patents and the agricultural GDP, first of all we have computed the linear relation.

$$\hat{y} = 676{,}98 + 27{,}8x$$

$$R^2 = 0{,}61$$

where: y = per hectare agricultural GDP, in €
x = per-hectare number of agricultural, biotechnological patents.

According to these data, the relatively strong correlation coefficient (r=0,783) shows that an increment by 1 in the per hectare number of patents will increase the value of per hectare agricultural GDP by EUR 27,80, i.e. by approximately HUF 8000.

In case of Hungary it means that if in 2000 we were be able to dispose of a per hectare number of R+D biotechnological patents equal to the EU average, then our per hectare GDP value might have been larger by HUF 5206, i.e. it would have been by 50 per cent above the that-time level.

For 2007 we can get a roughly similar image.

$$\hat{y} = 551{,}303 + 54{,}745x$$

$$R^2 = 0{,}54$$

According to these data, the application of a new patent in R+D activity has resulted in an increment of GDP by EUR 54,70, i.e. by HUF 15000 in 2007.

Finally, I would like to mention that the differentiation between countries can be considerably increased in the application of research results; however there is also a possibility of equalization, if the less developed countries will take special steps to make use of biotechnological results.

## 5. NEW OR NOVEL SCIENTIFIC RESULTS

**1**. By means of modern mathematic-statistical methods, I have demonstrated that both in 2000 and in 2008, in the EU member states:

- by the increment in per capita R+D expenditure, the per capita domestic product – having a very strong positive correlation (the value of $r^2$ has been equal to 0,94 in 2000 and to 0,67 in 2007) – will increase significantly, and the increment of R+D expenditure per agricultural worker will be accompanied by a definite increment in agricultural GDP (the value of $r^2$ has been equal to 0,58 in 2000 and to 0,76 in 2007).)
- by the increment in per hectare R+D expenditure, also the per hectare agricultural GDP will increase, thus the increment of intensity of research and development has a key role in the agriculture (the value of $r^2$ has been equal to 0,84 in 2000 and to 0,63 in 2007).

**2**. By means of modified C-D functions, I have demonstrated the role of agricultural R+D activity in the creation of agricultural GDP. According to my computations, the R+D expenditure has represented 12-14 per cent weight in the ruling-price GDP creation in the first decade of the 21$^{st}$ century.

**3.** The role of biotechnological research has been strengthening during the last years. At the same time, this effect can hardly be proved by means of functions in quantitative form. Partly this is due to the problems of multicollinearity. Therefore, I have made a separate bivariate regression analysis for the effect of biotechnological research.

There is a definite and strong correlation between the per hectare number of biotechnological patents and the per-hectare agricultural GDP, thus the role of biotechnology cannot be neglected in the increment of agricultural production. According to the regression parameters, in case of increment of the per-hectare number of patents increases by 1, the per-hectare agricultural GDP would have been increased by EUR 27,80 in 2000 and by EUR 54,75 in 2007.

# 6. PUBLICATION LIST OF MOHAMED ZSUZSANNA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9.Tóth, Tamás – Gorkovenko, Olga – **Mohamed, Zsuzsanna** (2006): The EU's Sugar CMO Reform and Hungary: Common Market, Common Agricultural Policy, Common Competitiveness. 295-302 p.International Scientific Days, Nitra 2006 ISBN 80-8069-704-3

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12.Bedéné Szőke Éva[a]-**Mohamed Zsuzsanna**[b]-Pallás Edit[c]–Takács Szabolcs[d] Optimization of biomass production on company level. *8th International Conference on Applied Informatics Eger, Hungary, January 27–30, 2010*

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13. **Mohamed, Zsuzsanna:** Műszaki fejlesztés és a termelési tényezők hozadéka. ( The technical development and the returns of production factors). In: Szűcs I. (szerk.) A tudományos megismerés rendszertana. Egyetemi jegyzet. SZIE GTK 2008. 272-281 o.

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15. Széles, Ivett – Zsarnóczai, J. Sándor – **Mohamed, Zsuzsanna** (2008): A Maros folyóvölgy környezeti viszonyainak vizsgálata (Analysis of environmental conditions of Maros River Valley).

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