# Technological progress and efficiency change In Hungarian Agriculture

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**TECHNOLOGICAL PROGRESS AND EFFICIENCY CHANGE IN HUNGARIAN AGRICULTURE**

**─Abstract ─**

Hungary became the member of European Union in 2004. The authors want to show that, though, many sectors of Hungarian agriculture have been operating at low level of technology and efficiency; there was a big expectation about the fast catching up with accession to European Union. This paper investigates the effect of EU membership on the productivity performance of Hungarian agriculture based on the years 2005 and 2009 using Data Envelopment Analyses and Malmquist index.

The analysis showed that there were considerable reserves of efficiency in the presented two main branches (wheat and pig fattening) of the Hungarian agriculture, and the reserves slightly decreased in wheat production, but they increased in the pig sector by EU accession. The implication for agricultural reform of future productivity growth has also been assessed.

**Key Words:** *total factor productivity*, *agriculture, EU membership*

## 1. INTRODUCTION

### 1.1. Importance of productivity in the agriculture

As the world tending toward liberalism, the competitiveness is the cornerstones of agricultural development strategies as well. One of the first-rank objectives of Common Agricultural Policy of EU is also to increase the vitality and competitiveness of agriculture, warranting the subsistence for the people living from agriculture, and to contribute to the present and future welfare of the whole society. Changes in productivity are of great importance at all levels –national, industrial, company and personal. The improving productive efficiency indicates the potential that exists for improving farm income. Because of the role of agriculture in the society our real income and living standard also critically depend upon the ability of agricultural sector to raise productivity. On a global scale, improved productivity is essential for sustainable development, to eliminate hunger, poverty and to protect the environment (Kendrick, 1993). In this context, the improvement of farm efficiency will be fundamental and the measurement of existing inefficiencies in agricultural production becomes much more important.

### 1.2. Importance of agriculture in Hungary

During the years from the accession the share of agriculture in the Hungarian GDP is between 4.1 and 2.8% and in the employment is around 4.5%. It is needed to mention that the Hungarian agrarian sector – although at decreasing rate – still represents a significant part of the economy comparing with other EU member countries. This is not a surprise because of its excellent natural resource endowments.

Hungary has a total area of 9.3 million hectares. In 2009, the cultivable area was 7,775,000 hectares, including forests, reed-beds and fishponds. The agricultural area amounted to 5,783,000 hectares, i.e. over 62%, which is considered high among the European countries. Seventy-eight percent of this cultivable area was arable land and

17% was grassland, while kitchen gardens, orchards and vineyards had a combined share of only 5%. Hungary produces cereals on half of its agricultural area while in the EU-27; an average only of one third of the agricultural area is devoted to cereal production. The Hungarian proportion of land used for cereal production is only exceeded in Poland (53%), Denmark (54%) and Finland (54%). The two main important crops are wheat and maize, with approximately equal share; they cover more than 50% of arable land area. The development in recent years has shown that yields are highly volatile mainly due to weather conditions.

Comparing the two main branches (crop and animal husbandry) the role of arable farming has become more important during the 1990s and the EU subsidy system made this process more visible. In 2005, almost 75% of economic organizations produced only crops and 25% of them bred livestock. During the same period 47% of individual farms focused exclusively on plant cultivation, while hardly more than 20% were engaged in animal husbandry and 32% conducted both activities. In both forms of farming, cattle- and pig-breeding were dominant in animal husbandry.

Bipolar economic structures, consisting of large-scale and small farms, also have to be mentioned as a special feature of Hungary's agricultural sector. Despite of duality in farm structure is of the land use is concentrated in Hungary. In 2009, 8.6% (15,900 farms) of the 185,200 farms applying for area payments used 72.1% of the designated agricultural area (FVM, 2006, 2007, 2009, KSH, 2010).

## 2. METHODOLOGY

### 2.1. Productivity measures

There are a number of theoretical studies and practical analytical works dealing with measurability of efficiency, with exploration of its factors and increment possibilities (Ball at al, 2001, Jet et al., 2000, Kawagoe, 1985, Pilot – Lepetit et al., 2003, Szűcs and Farkasné, 2008, Popp and Udovecz, 2006). A comprehensive study of Nábrádi contains a multitude of efficiency indicators and their application possibilities in agriculture (Nábrádi, 2008). Productivity measures can be classified into several major groups. The productivity measurement is usually conducted from the following two perspectives:

- level of productivity at a given point in time expressed by ratio of output and input and
- productivity trend, which shows the productivity development over time.

Most commonly used productivity ratio groups are

- partial productivity
- total factor productivity: the aggregate quantum of all outputs divided by the aggregate quantum of all of the inputs used to produce those outputs
- total social factor productivity which also refers the external or undesired effects production (Dobo et al., 2007).

Although the partial efficiency indicators – mostly used in practice – serve with useful information, they can often give a misleading overall picture. Their basic deficiency is that they disregard the interrelations between factors, their mutual strengthening or weakening effects. The increment of output per animal unit can be reached also by means of more intensive feeding; in that case the factor efficiency can remain unchanged, while the partial efficiency indicator is indicating an improvement (Capalbo and Antle, 1988).

This deficiency can be recovered by the production functions describing the input-output relations, which are suitable to measure all the changes in factor efficiency. From the practically used production functions, the Cobb-Douglas production function is mostly applied in agricultural analysis. Traditionally the so called “Solow residual” is used for measuring the full factor efficiency, and this remainder is equivalent to the same part of economic growth, which cannot be justified by the input growth. Beside the development of factor efficiency, it is also important to display the causing factors. For instance, the “residual”-member of Cobb-Douglas function indicates the technical and technological development, as well as the improvement of efficiency (Romer, 2002). Furthermore, this function requires special data, and its application raises certain difficulties, especially in case, when asymmetrical price-changes can happen because of administrative, or other – e.g. inflation – reasons.

Farrel rejected the idea of production functions describing the absolute efficiency, instead of them he suggested such a method, which measures the efficiency of examined unit in relative way comparing to the reference group reaching the best efficiency level. For the construction of production function (frontier), the stochastic function fitting or the DEA (Data Envelopment Analysis) is suitable Brümmer et al., 1998, Charnes et al., 1978, Coelli, 1996, Färe and Grosskopf, 1994). DEA uses linear programming to construct the efficient frontier with best performing observation of the sample used. The frontier surface is done by the solution of a sequence of linear programming problems.

The Malmquist index, which has been applied in this research, based on Farrel efficiency concept, is suitable for comparing the efficiencies between countries, regions and companies using means of measuring the distances between the input-output proportions of a given vector and the most effective examination unit found in the sample (the frontier).The main advantage of Malmquist approach does not require the assumption of efficient production, but instead identifies the ‘best-practice’ countries, regions or farms in every period, which gives an efficient production frontier, and measures each unit's output relative to the frontier.

This index may have an input or an output orientation, and is suitable to break down the full change in factor productivity into its components. For output oriented case the DEA approach seeks the maximum proportional increase in output of production with input level held in constant. In that case, we have preceded according to the attitude “the greatest quantity from the same input”. However, the efficiency changes can be examined also by seeking the maximum possible proportional reduction in input usage, with output level held in constant for each farms. In such case we are guided by the principle “the same quantity from the fewest”. It is the so called input-oriented procedure.

The Malmquist can be decomposed into two components technical efficiency change and technical change. The value of decomposition is that provide information about the sources of productivity change, additionally DEA allows decomposing the index of technical efficiency change into pure technical efficiency change and scale efficiency change by running linear programming under constant return to scale and variable return to scale. The pure technical efficiency captures the efficiency of management practices while the scale efficiency shows whether the farm operates under the optimal size (Balcombe et al., 2005, Fogarasi and Latruffe, 2007). An analysis of the determinants of relative efficiency indicates which aspects of the farming could targeted in order to improve farm efficiency

In the international literature more and more examples can be found for the application of Malmquist index in agricultural economy, and in the recent years we can also find some Hungarian appliers among the publications, although their number is quite limited. (Capalbo and Antle, 1988, Carter and Zhang, 1994, Coelli et al, 2006, Dobó et al., 2007, Fogarasi and Latruffe, 2007, Lissitsa et al., 2006, Pilot – Lepetit et al., 2003, Tonini 2005, Varga, 2006).

This study attempts to contribute to the literatures employing Malmquist productivity index, using this methodology on product level in Hungarian agriculture. Our investigations have been made according to output-oriented concept (for one product and several production factors) therefore the interpretation of components will be discussed from such an approach.

### 2.2. Interpretation of output-oriented Malmquist index and its decomposition

#### Output-oriented Malmquist index

The output-oriented Malmquist index presents on all input levels (x) the distance between the performances of the unit with best result and of the given unit (y) on the technological levels belonging to t and t+1 years. The output oriented Malmquist index compares the input-quantities used for given output by means of distance-functions (difference between the smallest input spending and that of the examined unit). In the herewith presented application, we used the output oriented indicator.

The output oriented Malmquist index ($M_O$) is as follows:

$$M_0^{t+1} = \left[ \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \right]^{1/2}$$

This index can be broken down to two components:

$$M_0^{t+1} = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \left[ \frac{D_0^t(x^{t+1}, y^{t+1}}{D_0^{t+1}(x^{t+1}, y^{t+1}} \frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)} \right]^{1/2},$$

namely, the catching-up or technical-technological efficiency index (Technical Efficiency Change) and in the brackets to the TC index (Technical Change). By means of differences in functions, we can construct by postulating the constant and variable return to scale. There are many different programs that could be used to measure the distance function, which make up Malmquist productivity index. For our analysis the DEAP 2.1 version computer program has been used.

## Components of Malmquist index

As we have seen in the foregoing, the Malmquist index is an indicator, which can be applied properly of changes in time and in extension of full factor efficiency. The present application concentrates on the changes in time. In that form it can be broken down to components, i.e. to further indices having well definable economic contents in themselves. In the first step the change in total factor efficiency (TFPC) can be broken down to two components, namely to that of technological change (TC) and to the component of technical efficiency change (TEC).

TFPC = TC*TEC.

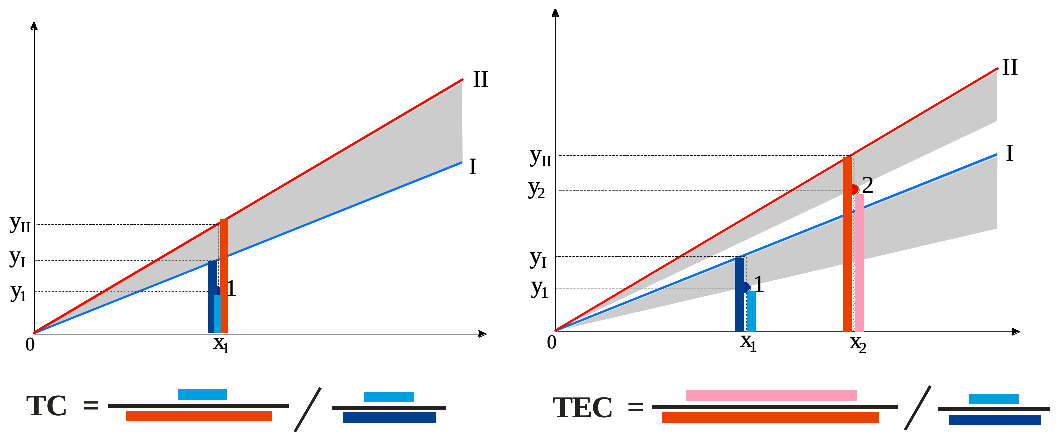
During the computation of technological change, we make use of co-ordinate proportions between the production factors' values and the curve containing the convenient values of first-rank farms (Figure 1.). In that Figure, we bring into comparison the situation in the first period of a given farm to the straight lines in the first (t=I) and second (t+1=II) period of first-rank farms, on the basis of co-ordinate proportions of y product and of x vector embodying a combination between production factors:
Technical change is defined as the movement of the production frontier, as measured by best practice farms within the sample, over time.

$$TC = (y_1 / y_I)/(y_1 / y_{II})$$

In case of a given farm, the TC proportion quotient indicates the technical-technological change for all the farms – symbolically – the grey stripe in Figure 1a. If the value of average proportion quotient calculated for several farms is equal to one, it means that the technical level has not changed, if this indicator is higher than one, it indicates the improvement, in other case the degradation of technical level for farms the represented of.
best practise in the sample.

**Figure-1: Geometric interpretation of Malmquist index decomposition**

**a. The technological change TC** **b. The change in technical efficiency TEC**



To the change of technical efficiency, we bring into comparison the values of farms in two time periods ($y_1$and $y_2$) to the value curves of first-rank farms of the same periods ($y_I$ and $y_{II}$) as it is visible on the Figure 1.b. Between the two time points the farms have moved from the point 1. to point 2. we compare the co-ordinate proportions of point 1 to the curve I ($y_I y_1$) and of point 2 to the curve II ($y_2 y_{II}$):

$$TEC = (y_1 / y_I)/(y_2 / y_{II})$$

In case of one farm, the change of technical efficiency will be indicated by TEC co-ordinate proportion, and for all the farms – symbolically – by the proportion of grey stripes. If the value of average proportion quotient calculated for several farms is equal to one, it means that the efficiency has not changed, if this indicator is higher than one, it indicates the improvement, the other case the degradation of technical level for the whole population of farms.

In the foregoing, we have designated the curves of first-rank farms with straight lines. This simplification has been able to justify so far, as we suppose that each farm is functioning in the state of constant return to scale (CRS). It means that all the farms use each of their production factors in technical optimum level. In that case, the whole production and each farm have optimum size, or function with adequate capacity. It is an ideal condition, i.e., the state of perfect market and of the Pareto optimum. However, in practice, we have to reckon (for certain reasons not detailed here) with changing scale efficiency of producers.

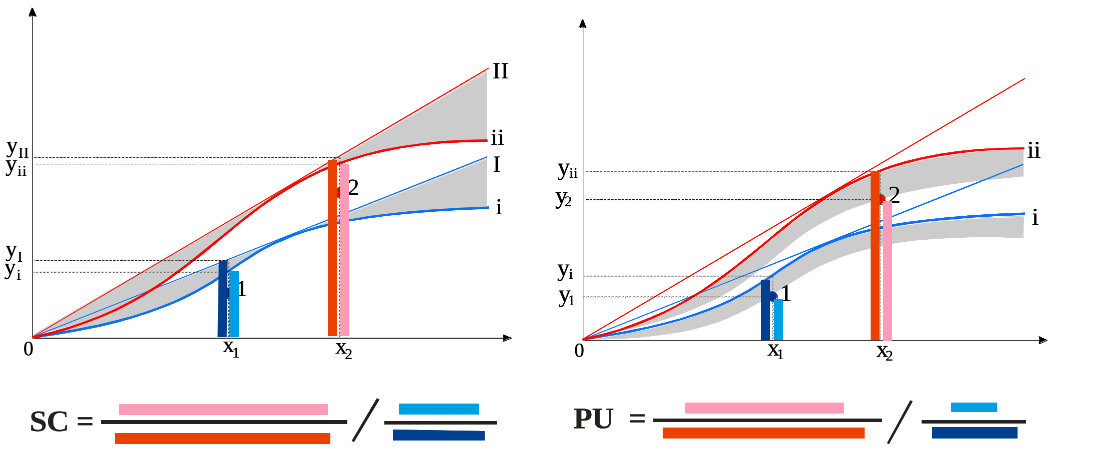
The state of variable returns of scale (VRS) during the development of a farm – from the beginning till the technological maximum – can be described by an S-shaped growth curve, and the majority of farms is to be found somewhere in the upper, regressively increasing section of this curve, above the inflexion point. In the Figure 2.a. – guided by the former logic of representation – we have applied the i and ii curves of variable returns of scale as comparison bases, instead of I and II curves of constant returns of scale. In that case, the index of change in scale efficiency (SC) can be described as follows:

$$SC = (y_i / y_I)/(y_{ii} / y_{II})$$

**Figure-2: Geometric interpretation of technical efficiency and its decomposition**

**a. Change in the scale efficiency SC**

**b. Change in the pure technical efficiency PU**



What remains after having taken out the scale efficiency is the indicator of change in pure technical efficiency (PU). Thus the change in technical efficiency consists of the following two components:

TEC = SC*PU

The indicator of the change in pure technical efficiency is an integrated indicator of all, formerly disregarded differences in efficiency. For instance, the backwardness of management level of a given farm in comparison to first-rank farms, the overfeed of natural factors, the break of technological discipline, as well as the lack of working experience can be counted among such indicators.

$PU = (y_1/y_i)/(y_2/y_{ii})$

The determination of backwardness for above mentioned reasons in comparison to the first-rank farms can be traced – guided by the former logic – in the Figure 2.b.

## 3. PRODUCTIVITY OF THE HUNGARIAN AGRICULTURE

Hungary became member of EU in 2004. As in all member states EU the development of agriculture driven mainly by actual Common Agricultural Policy and its future reforms. In the five years after EU accession Hungarian crop producers faced increasing input cost, changes in output prices, increasing competition in the single market of EU and they also received higher subsidies, if they are to fit to the criteria of cross compliancy.

Although many studies have been conducted to analyse the impacts of EU membership on Hungarian agriculture, only few studies have been done on the impacts of Common Agricultural Policy (CAP) on farm economic performance in term of efficiency and productivity. During our research work, we wanted to know what changes were brought by the EU accession in the field of technological development and efficiency of resources use. The nonparametric production frontier model applied here allows for a simultaneous estimation of total factor productivity and the impact of factors determining that, in the environment with high uncertainty of input and out prices and their reliability.

We made the same investigations for several other branches, herewith we outline only the result for two prominent branches, i.e. for wheat and pig production. Our calculation is based on the Hungarian Farm Accountancy Data Network's (FADN) for years 2005, 2009, among the farms engaged in the given activity of examined years. The detailed farm level data set used for this research involved 491 specified wheat producing farms (represented in FADN both of examined two years) and 76 commercial husbandry farms, with specialization for pig fattening.

We used the output of mentioned branches of farms as single integrated data, with the assumption of products homogeneity. Among the plant production expenditures we took into consideration the production area in gold crown value (Hungarian measurement used for emphasizes of land quality), seeds, fertilizers, plant-protecting materials, fuel, labor, depreciation, and the overhead of examined activity on farm level. The output of pig fattening has been measured by the increase in weight, and the input vector including basic materials, the purchased and the farm produced animal feed, costs of animal health and of energy, labor expenditure, depreciation, and the overhead cost of pig fatting activity and of the whole farm.

Indexes applied have been formulated on per hectare and 1 tone pigs for slaughter basis. Deflated values (adjusted by core inflation) of income and cost data have been used. Based on the data of the Hungarian Statistic Department the value of core inflation was set at the level of 1.208 (for the period of 2005-2009).

We made the same examinations in classification for private and corporate farms, furthermore for regions on NUTS 2 level.

### 3.1. Total factor productivity in wheat production

Our analysis indicates that accession had only a small impact on productivity of Hungarian crop production. For wheat production – despite of unfavorable weather in 2009 - the value of change in full factor efficiency (TFPC) is positive, 3.7 % in national average. Table 1 shows the results in details for the whole industry and for the farm groups by legal forms.

**Table 1: Malmquist Total Factor Productivity index and its component in Hungarian wheat production (2005-2009)**

| **LEGAL FORMS OF FARMS** | **TFPC** | **TC** | **TEC** | **SC** | **PU** |
|---|---|---|---|---|---|
| Individual farms | 5.1 | 1.9 | 3.1 | 4.3 | 0.8 |
| Corporate farms | 2.3 | 0.9 | 2.4 | 4.8 | 0.5 |
| **All together** | **3.7** | **1.3** | **2.8** | **4.6** | **0.6** |

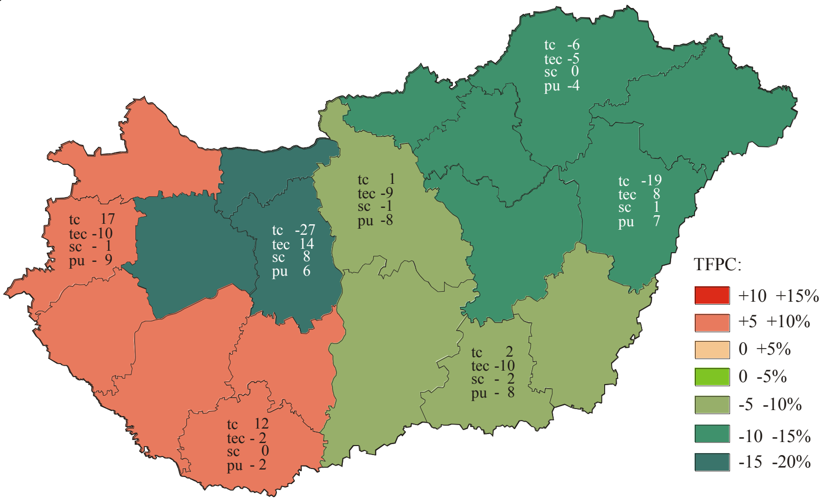
Source: Authors own calculation

Examining the components of TFPC indicator, we can state that the general increase took place in spite of a small (1.3 per cent) increase in technological level (TC) of farm represented the best practice. Firms not included in the category of leaders had a bigger development rate, which shown by change in technical efficiency (2.8%).
Based on the main conclusions of previous related studies can be stated that the biggest share in TFPC had the technological change. In our case the higher share came from more efficient use of inputs, which can be interpreted in different way. The farm represented the best practice improved their technology during the accession period, or other possible conclusion is that in maximizing farm income the claiming eligibility for direct payments and agri-environmental schemes required capital formation which did not affect directly on productivity. For an intensive farm, with high level of industrial inputs, could be rational to accept a higher level of technical inefficiency in order to meet the qualifying condition for direct payments (O'Neill, et al., 2008). But also an accepted conclusion can be that because of unfavorable change

in environment with increasing risk in the market they willingness to invest does not increased despite of increasing net income. One possible reason of this should also be that the weather impact is not distinguished from economic changes in efficiency measures and the year 2009 was unfavorable for wheat production compering with 2005. However, on the basis of the figures in Table 1 we can see that the first-rank individual farms performance better compering with corporate farms. Increasing farm size of farms and decreasing land fragmentation can explain that the biggest improvement shown by scale efficiency indicator. At the same time it can be sad that after five years of accession, the managements haven't succeeded in fitting their production systems to these new levels of developments, the PU increased by less than 1 percent. Further research is needed in this direction. We may be able to draw some political implication of CAP reform based on empirical studies for other countries that the decupled subsidy might not have positive impacts on the technical efficiency in at least for Belgium, Nederland, Sweden, Germany and Ireland (Coelli, 2006**,** Xueqin, 2008, O'Neill, et al., 2008). As the main conclusion of our study we can state that there is only very small change in productivity of wheat production which is not enough for catching up to our competitors.

The results of investigation according regions show the development of changes in efficiency along with the "front-rank" regions as it is shown in Figure 3.

**Figure-3: Regional differences in productivity change of wheat production (2005-2009) based on the NUTS 2 level**




### 3.2. Total factor productivity in pig fattening

**A brief overview of pig sector**

In the past the pig sector has accounted for more than half of the value of output of livestock in Hungary. With becoming a member of the European Union the Hungarian regulation of animal production has been changed. However this has not lead to developments in the pig production because subsidies under the CAP are not provided in this sub-segment of the agriculture while the national payments that existed previously became no longer available or/and became limited. The uncertainties attached to the sales, the high costs of fodder and the new standards have been put in place due to our EU membership have a significant negative effect on pig subsector. The losses led to the tendency of farmers giving up their businesses, for which reason Hungary stopped being net exporter and became net importer on the market.

It can be said that livestock still suffering from the transition shock and the its state is worsening as a consequence of changing market situation in the world and in the single market of EU. As far as changes in world market are concerned, the declining of livestock sector in Hungary should be highlighted (Udovecz et al., 2007). Although the growth of concentration in the domestic pig stock has been started but the sector is still fragmented and in the same time there is a lack of cooperation too. Overall the sector lost a lot due to the membership. Leaders of the sector are currently working on an action plan with the aim of saving the domestic market, which hopefully will be able to turn back/stop the unfavourable process.

## Change in total factor productivity

The pig fattening is in a negative process compared with wheat production, namely the TFPC deterioration, with high negative trend in in technical change, improvement in TEC can be observed, together with a smaller increase in PU and a little bit larger one in SC (Table 2, Figure 4).

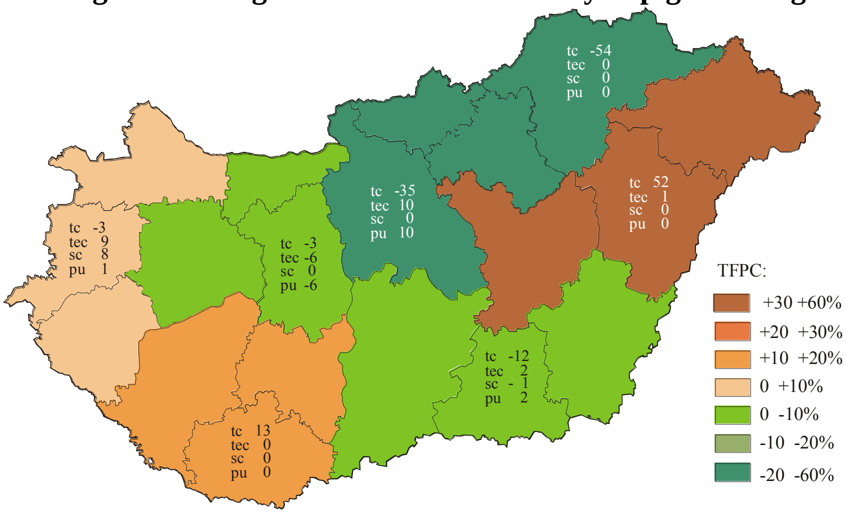
**Table 2: Change of efficiency in pig fattening by legal form (2005-09)**

| Company form | TFPC | TC | TEC | SC | PU |
|---|---|---|---|---|---|
| Private farms | -2.7 | -6.4 | 3.6 | 2.7 | 1.1 |
| Agricultural enterprises | -17.5 | -23.8 | 8.3 | 4.0 | 4.1 |
| **Altogether** | **-3.5** | **-7.0** | **3.8** | **2.7** | **1.2** |

Source: Authors' calculations

The results of investigation according regions show the development of changes in efficiency along with the "front-rank" regions as it is shown in Figure 3. The decreasing homogeneity of Hungarian farms and regions suggesting that large part of farmers and regions were not able to adapt their practices to the situation brought by EU accession. A deeper analysis of dispersions behind the average indicators and the reasons requires further research work.

**Figure-4: Regional Change of total factor efficiency in pig fattening**



## 4. CONCLUSIONS

Our analysis, carried out by means of the Malmquist index, can show that there are considerable reserves of efficiency in the presented two branches of Hungarian agriculture, and those reserves have not decreased during the post accession period despite of overall income growth of agricultural sector. The decreasing homogeneity of Hungarian farms and regions suggesting that large part of farmers and regions were not able to adapt their practices to the situation brought by EU accession. Our result also has a statement that at list one part of Hungarian catching up problems was down to other reason as farm management weaknesses and partly small-scale farm structures, not just capital formation. Nevertheless, our investigations show the awkwardness of the development of agriculture that the EU, in case of new member states, is supporting – by the aids aiming the increment of their social acceptance (welfare-increasing, environmental-pollution moderating effect) – such national agricultural branches, which – contrarily these branches in old member states – would need yet efficiency-improving development as well. The investment costs of meeting EU environmental standards (manure treatment and food safety regulations) run to millions and even these investment just entitling farmers to participate in the single market of EU, without any positive effect on productivity.

According to the environmental damages (in particular drought) were higher in 2009 than 4 years earlier in 2005, although TFP index improved in the case of wheat cultivation. The volume of fertilizers used decreased while their value increased by/to 1.7-1.9 fold. At the case of pig production the consumption of feed mixture decreased but in the same time costs increased by more than 150%. These tendencies suggest that the modest efficiency improvement in wheat cultivation and the significant efficiency decrease in pig production provide a worsen picture than in overall terms. However due to the changeable weather condition the increasing volatility of prices and yields there has been major up and down in catching of process, but our final conclusion is that Hungarian agricultural economy is more likely to be on the path to lagging behind than catching up.

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