Agricultural basic industry subjects productivity development examination in the region Trnava (SR) by adopting the Malmquist indexes

Skúmanie vývoja produktivity poľnohospodárskej prvovýroby v regióne Trnava aplikáciou Malmquistových indexov

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Abstract: Analysis of the productivity and efficiency development could be used to asses the trend and factors influencing this process. The main goal of this paper is estimation of the Total Factor Productivity (TFP) development of agricultural farms in the Trnava region in the period 2002–2006. Results of this analysis could be used to detect the trend in the TFP development. The results of the analysis confirmed there is no evident trend in the average TFP indicators. This could be explained by the variation of technical efficiency change and technological changes during this period. These two factors represent the components of the TFP indicator. According to the present development of the TFP indicator, it is not possible to unambiguously forecast the future trend.

Key words: Total Factor Productivity (TFP), technical efficiency change, technological change, Malmquist index

Abstrakt: Skúmanie vývoja produktivity a efektívnosti výrobného procesu v čase môže poskytnúť informácie o trende, ale aj o jednotlivých zložkách, ktoré majú vplyv na celkový vývoj. Cieľom príspevku bol odhad vývoja celkovej produktivity subjektov poľnohospodárskej prvovýroby v regióne Trnava v rokoch 2002–2006 a identifikácia vývojových trendov v regióne. Vzhľadom na výrobné podmienky a technickú vybavenosť poľnohospodárskych podnikov v regióne Trnava, v porovnaní s výrobnými podmienkami a priemernou technickou vybavenosťou podnikov v SR, sa nepredpokladali podstatné zmeny vo vývoji celkovej produktivity faktorov (TFP). Potvrdzuje to aj priemerná hodnota TFP, ktorá sa v sledovanom období pohybovala na približne rovnakej úrovni. Vývoj úhrnného faktora produktivity vyjadreného TFP za celý súbor analyzovaných podnikov bol ovplyvnený hlavne zavádzaním nových technológií. TFP vykazoval v sledovanom období kolísavý vývoj, ktorý bol ovplyvnený zmenami v jeho jednotlivých zložkách. Z doterajšieho vývoja TFP preto nemožno jednoznačne odhadnúť budúci trend.

Kľúčové slová: celková produktivita faktorov (TFP), zmena technickej efektívnosti, technologická zmena, Malmquistov index

Dynamic environment, where the agricultural companies are operating in the Slovak Republic after the accession into the European Union, requires continuity in increasing efficiency of the production process for the preservation and growth of the domestic producers' competitiveness in the single agrarian market. Slovak agriculture has undergone the transition period which left negative consequences on the agricultural production reduction including the drop of employment in agricultural basic industry.

The process of stabilisation and the production and productivity growth started in the year 2004 after the accession of the new member states into the EU by the reduction of the number employees in agriculture, creation of new institutions and market relations stabilisation (Swinnen and Vranken 2005).

There exist many opinions on the relation between the productivity development (efficiency) and legal forms in the transition economies. Petrick and Weingarten (2004) maintain a position that countries

in which the companies with the large area of cultivated land from centrally planned economy period were preserved but which simultaneously adapted their organizational structure to the new system and optimized the number of employees to reach a higher efficiency measure.

One of the factors, which influenced sustaining higher measures of efficiency in these countries, is keeping the know-how of the prospering companies. Similar conclusions were reached also by Swinnen and Vranken (2005) according to the technical efficiency measures estimation in countries of the Central and Eastern Europe (CEEC). Countries as the Czech Republic, the Slovak Republic and Hungary, in which large agricultural companies were sustained, reached higher average technical efficiency measures in comparison with the transition countries.

One of the appropriate indicators for the productivity development estimation is the Total Factor Productivity Index (TFP). To estimate the TFP, there are mostly used the Tornquist-Fisher Indexes (*TFi*) and the Malmquist indexes (*Mi*). There are some advantages of the Malmquist indexes over the Tornquist-Fisher Indexes. The application of *Mi* is not expecting that all analysed subjects are simultaneously technically and allocatively effective what is the basic assumption of *TFi.* Applying *Mi* is not expecting the profit maximization as an essential condition and also it does not require the information about input prices used in the production process (Coelli et al. 2005).

There exist many examples of the TFP indexes application on the basis *Mi* at regional level as well as on the firms' level. As one of the most known analyses at the regional level, we can mention the work of Coelli and Prasada-Rao (2003) where the development of TFP was analysed in 97 countries during the period 1980–1995. Yearly increase of TFP during the analysed period represented 2.7% which was caused mainly by the technical effectiveness change.

Mi application at the companies' level with wheat growing orientation in Slovakia was applied in the research of Fandel (2002). The TFP index development during the period 1996–2000 with the sample of the observed companies balanced and its decline or increase was affected by both *Mi* components.

Lissitsa and Rungsuriyawiboon (2006) estimated applying the parametric method SFA the TFP index of agricultural production development in 46 countries (EU-15, EU-10, Turkey and the transforming countries of the former Soviet Union) during the period 1992–2002. As the main conclusions from their study we can state, that the biggest share in TFP increase had the technological change in all monitored countries. All the transforming countries including the EU-10 achieved a higher average increase of technical effectiveness in comparison with the EU-15 countries.

Horská (2004) analyzed in her research the impact of globalization on the business practices as the sources of efficiency and competitive advantages.

In the EU-27, the value of agricultural output in basic prices in 2008 grew by 3.9%, mainly due to an increase in the value of both crop production (+2.9%) and animal production (+5.5%) in the real terms (Bielik et al. 2009).

Ciaian et al. (2009) comparing the efficiency of family and corporate farms stated that the transaction costs of using markets should also be taken into consideration. In many transition countries, the output markets suit better the large corporate farms and prevent the development of family farms.

MATERIAL AND METHODS

The objective of research is the total productivity development estimation of the basic industry subjects in the region Trnava in the Slovak Republic during the period 2002–2006 and the identification of the development trends. The data were obtained from the Central Database of the Ministry of Agriculture of the Slovak Republic (Information Letters of the MoA SR for the period 2002–2006). Five companies[1] were excluded from the whole dataset by applying the sensitivity analysis. The excluded companies (all of them were the limited liability companies) were specific by their production orientation which significantly differentiated from the production orientation characteristic for other companies in the analysed region.

For the Malmquist indexes – *Mi* calculation, there was selected one output – total revenues and four inputs – cultivated land according to the LPIS, the average number of employees, the aggregated input depreciation and amortization plus the costs of services and material and energy usage.

Total productivity estimation applying the Malmquist indexes

Malmquist indexes (*Mi*) are based on measuring the radial distances of the input or output combinations during the period *s* and *t* considering the reference

[1]outlayers

technology. *Mi* can be, according to the analysis aim, estimated from two points of view (input *Mi* and output *Mi*). In this paper, there was applied input *Mi* for the reason that we examined the increase of the companies' effectiveness by input reduction what in comparison with output maximization we consider a better way of increasing competitiveness.

Input oriented *Mi* is aimed on the input level needed to produce the output q_s and q_t combination regarding to the reference technology. In case we will apply time period *s* as the basic, *Mi* will reach the following form

$$m_i^s(q_s, q_t, x_s, x_t) = \frac{d_i^s(q_t, x_t)}{d_i^s(q_s, x_s)} \quad (1)$$

where $d_i^s = (q_t, x_t)$ a represent the firm's production effectiveness in the period *t* by applying the technology from the period *s* and $d_i^s = (q_s, x_s)$ represent the firm's effectiveness in the period *s* by applying the technology from the period *s*.

In case if firm is effectively in both periods, $d_i^s = (q_s, x_s) = 1$, then *Mi* reached the form

$$m_i^s(q_s, q_t, x_s, x_t) = d_i^s(q_t, x_t) \quad (2)$$

With a similar method is possible to define also *Mi* with the reference period *t* but it also is possible to apply the specification of input *Mi* which is geometric mean *Mi* in the periods *s* and *t* (Caves et al. 1982).

$$m_i(q_s, q_t, x_s, x_t) = \left[m_i^s(q_s, q_t, x_s, x_t) \times m_i^t(q_s, q_t, x_s, x_t)\right]^{\frac{1}{2}} \quad (3)$$

In the case we want to estimate *Mi* on the basis of the previous equation, we need to estimate four radial measures considering the production frontier defined in the equation 1. Only in case the firms are effective in both periods, it is possible to estimate this relation by two measures. As the biggest problem of the *Mi* estimation, we can determine the knowledge of technology during the analysed periods (the necessity to exactly specify the form of the production function). According to this fact, it is necessary to obtain the detailed information about inputs and outputs at the enterprise level and also about the production function estimation methodology which are not requiring the individual firm efficiency prerequisite.

The equation 2 is a simplified version of *Mi* in which we assumed that firms are effective in both periods. But if we assume the possibility that a firm could be not effective, it is possible to define two components influencing the productivity (TFP) changes of the individual firms as the change of effectiveness and technology. After revisions, the input *Mi* reached the form

$$m_i(q_s, q_t, x_s, x_t) = \frac{d_i^t(x_t, q_t)}{d_i^s(x_s, q_s)} \left[\frac{d_i^s(x_t, q_t)}{d_i^t(x_t, q_t)} \times \frac{d_i^s(x_s, q_s)}{d_i^t(x_s, q_s)}\right]^{\frac{1}{2}} \quad (4)$$

where the formula outside the brackets represents the change of technical efficiency (Farell technical efficiency) during the period *t* and *s*. This measure is interesting from the aspect that it shows us how the input using in the concrete companies improved with time change and whether the positive change of technical efficiency (if the equation reached value greater than one) or negative change (value is lower than one) is reached.

Part of the equation in square brackets represents the technological change measure. It is the geometric mean of the technology movement between the analysed periods x_s and x_t.

To estimate the input *Mi* in the paper, there was applied the nonparametric method Data Envelope Analysis (DEA) which is based on linear programming. An advantage of this method is that we do not need to specify the production function form which is estimated by linear programming (Färe et al. 1994).

RESULTS AND DISCUSSION

This part is oriented on the productivity development examination of basic industry subjects in the region Trnava based on the Total Factor Productivity – TFP estimated by the Malmquist indexes. The base file comprised of 58 companies in the analysed period 2002–2006. In Table 1, there are reported basic descriptive statistics of the analysed data set.

The value of the procured investments into agricultural companies in the region Trnava increased during the analysed period mainly as a consequence of the programs SAPARD[2] and SOP P-RV[3]. The increase of investments is possible to examine through the depreciation and amortization development (in-

[2]The Agricultural Payment Agency finished finalizing the contracts of the finance aid in the framework of the SAPARD program keeping with the decree of the Commission No. 447/2004 from 12th May 2004, nevertheless, financing of the accepted projects has continued till the end of the year 2006.

[3]The highest share from the total value of financial resources was spent for the proceedings: Investments into agricultural companies (SAPARD – No. 1 and SOP P-RV – No. 1.1) and Improvement of processing and marketability of agricultural products (SAPARD – No. 2 and SOP P-RV – No. 1.2).

crease by 22.89% in comparison with year 2002). Restructuring of agricultural companies and the new technologies introduction impacted the number of employee reduction. During the period 2002–2006, the number of employees in the agricultural basic industry decreased in the region Trnava by 27.05%.

During the analysed period, the increase of input prices into agriculture continued mainly due to the increase of fuel, feeds, seeds, fertilizers and plant protection prices. New technologies implementation (in crop production) had a favourable impact on the fuel usage decrease, however, the total material and energy usage did not decrease due to the increase of diesel prices (by 29.1% in the year 2006).

Significant changes which in final consequences influenced the TFP development were recorded in the case of revenues which as an output were influenced by natural conditions (especially due to the weather influence during the growing season) during the individual years.

In Table 2 and Figures 1–9, we can study the fluctuating development of the TFP and its individual components for the whole analysed data file as well as by segmentation according to the legal form, production orientation and size.

The Total Factor Productivity development for the whole data set of analysed companies was influenced mainly by the new technologies introduction. This fact is recorded in Table 2 and Figures 1–9, which represent a higher measure of dependence between the technical change and TFP in comparison with the technical efficiency change and TFP. The TFP shows

Table 1. Descriptive statistics of output and inputs for whole analysed data file during period 2002–2006

	2002	2003	2004	2005	2006
Revenues (incomes) total in thousands SKK					
Mean value	48 090	46 139	47 254	49 657	49 205
Standard deviation	36 653	37 018	39 509	39 129	42 396
Minimum	3 044	2 030	4 595	1 372	1 727
Maximum	151 314	153 223	159 899	160 962	194 975
Farmed land according to the LPIS (farmed land in utilization) in ha					
Mean value	1 226	1 210	1 188	1 189	1 221
Standard deviation	849	856	822	818	812
Minimum	60	60	61	65	65
Maximum	4 338	4 370	3 868	3 846	3 855
Average number of employees					
Mean value	72	66	60	57	52
Standard deviation	61	57	55	52	47
Minimum	3	2	2	2	2
Maximum	318	294	284	268	250
Depreciation and Amortization plus costs at services total in thousands SKK					
Mean value	13 865	14 975	14 975	16 513	17 039
Standard deviation	11 789	13 309	13 411	14 786	15 921
Minimum	973	791	1 119	1 408	1 219
Maximum	51 690	58 945	63 986	70 441	82 833
Material and energy usage total in thousands SKK					
Mean value	26 190	25 100	25 108	26 905	27 340
Standard deviation	21 831	21 074	22 163	23 179	24 055
Minimum	1 542	1 783	917	461	975
Maximum	99 834	99 164	101 368	109 363	108 912

Source: Own calculations

Table 2. Descriptive statistics of TFP development and its components in analysed data file during period 2002–2006

	2003/2002	2004/2003	2005/2004	2006/2005	*Mean*
Technical efficiency change					
Mean value	0.935	0.992	0.979	1.109	*1.002*
Standard deviation	0.125	0.179	0.166	0.160	
Minimum	0.609	0.592	0.724	0.781	
Maximum	1.334	1.549	1.702	1.439	
Technical change					
Mean value	1.001	1.084	1.056	0.853	*0.994*
Standard deviation	0.030	0.049	0.131	0.078	
Minimum	0.901	0.978	0.970	0.663	
Maximum	1.076	1.226	1.828	1.113	
TFP change					
Mean value	0.936	1.076	1.033	0.947	*0.996*
Standard deviation	0.133	0.207	0.214	0.143	
Minimum	0.606	0.633	0.772	0,598	
Maximum	1.436	1.686	1.882	1.285	

Source: Own calculations

during analysed period fluctuating development which was influenced with its individual components changes. Therefore, it is not possible from the existing TFP development to unambiguously estimate the future trend.

We do not assume, according to the production conditions and technical facilities of agricultural enterprises in the region Trnava in comparison with the production conditions and average technical facilities of Slovak companies in total, significant changes in the TFP. It confirms also the average value of the TFP which was fluctuating during the analysed period at approximately the same level (decline by 0.37%). The TFP change was influenced mainly by the higher decrease of technical efficiency change more than the technical change and contrariwise. From this reason, there was not identified in the case of the TFP the key factor which had the unambiguous impact on the TFP during the analysed period.

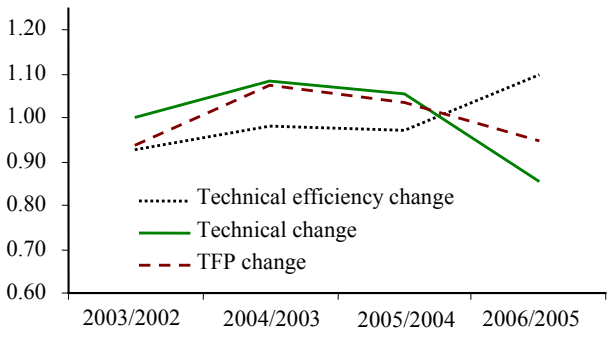

Figure 1. TFP development – the whole dataset

Source: Own calculations

Technical change is connected not only with new technologies the introduction of which relates to investments into technological facilities of agricultural companies (observed through depreciation), but mainly with the increase/decrease of output (revenues). The decrease of revenues for sold own products was during the analyzed period caused by drought in the years 2003 and 2005, which was connected with the decline of revenues from the crop and animal production.

The region Trnava is characteristic by a considerable representation of stock breeders which can be identified by a moderate increase of beef cattle as well as by the increase of the utility parameters.[4] The mentioned drought in the year 2005 caused the decrease of volume fodder production what was consequently followed by the decline of the revenues from milk as well as the total revenues from animal production in the year 2006.

[4]The number of cattle in the Slovak Republic in year 2006 still declined and reproductive parameters simultaneously worsen.

We can observe in Figures 2–4 TFP index development and its components according to the individual legal forms.

As in the case of the whole dataset of the analysed companies, also by the individual legal forms it is possible to observe an almost zero average TFP increase. In case of agricultural cooperatives and limited liability companies, the value of the TFP decreased during the first period based on the decline of technical efficiency change in comparison with the previous period. This fact is probably caused by bad climate conditions in the year 2003 and followed by inefficient inputs utilization in the production process.

The TFP development in case of the joint-stock companies was not identical with the total development as well as with the development of the other two legal forms. The main difference is the positive growth of the TFP during the first and last year which has not occurred in the previous cases. The reason of the decreasing TFP value in case of agricultural

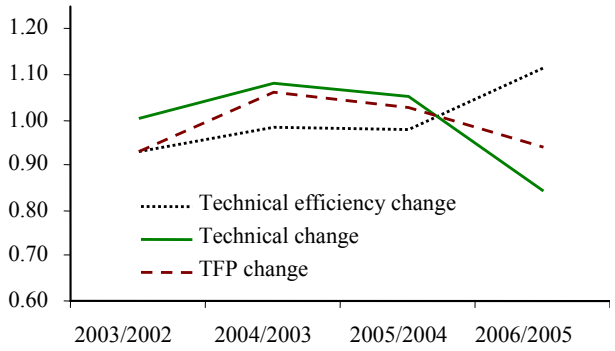

Figure 2. TFP development – agricultural cooperatives

Source: Own calculations

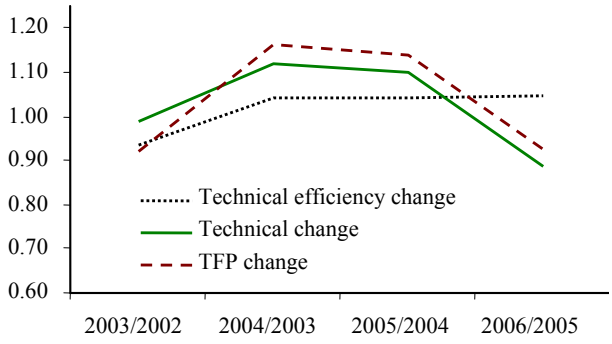

Figure 3. TFP development – Ltd.

Source: Own calculations

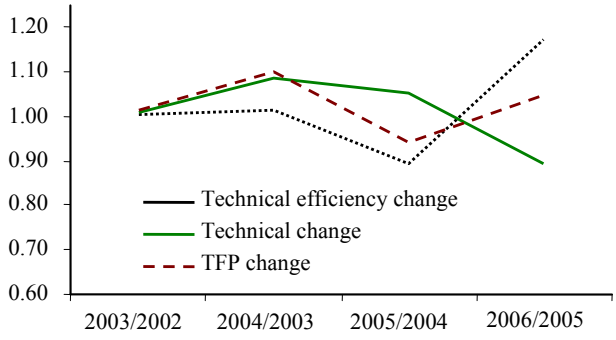

Figure 4. TFP development – Unltd.

Source: Own calculations

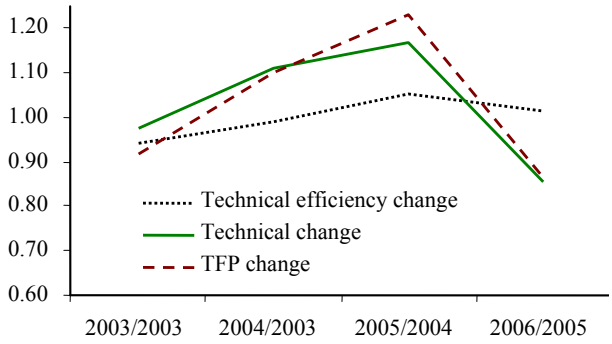

Figure 5. TFP development – crop production

Source: Own calculations

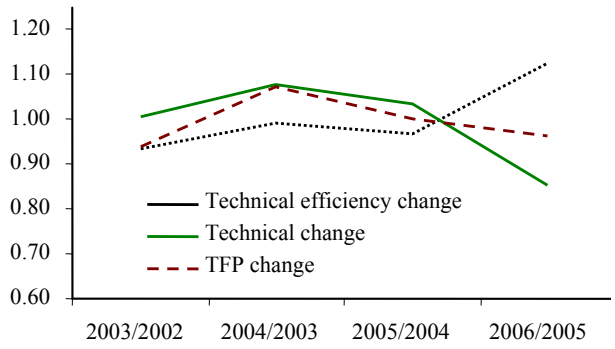

Figure 6. TFP development – crop and animal

Source: Own calculations

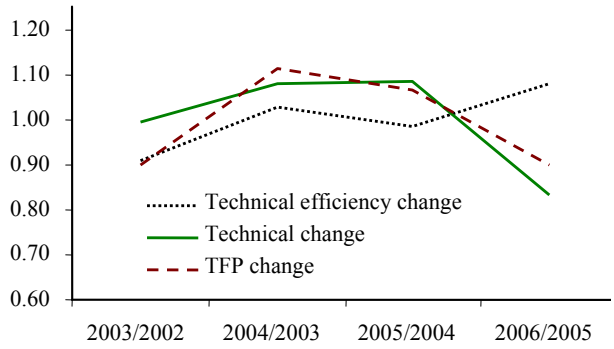

Figure 7. TFP development – till 1 000 ha

Source: Own calculations

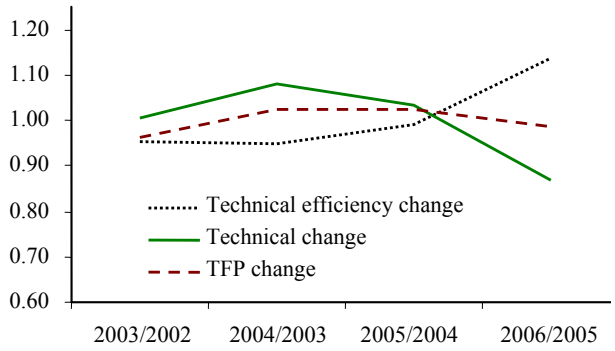

Figure 8. TFP development – 1 000–2 000 ha

Source: Own calculations

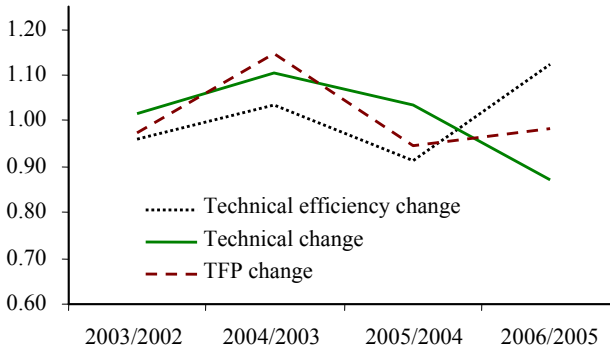

Figure 9. TFP development – over 2 000 ha

Source: Own calculations

cooperatives and limited liability companies during the last period was technological change, in comparison with the group of the joint-stock companies where TFP increased due to a higher change of technical efficiency against the decreased technological change.

A positive trend is that in all legal forms the stabilisation and progressive increase of technical efficiency change can be observed. This fact can be used as an indicator of the progressive management fitting to the new conditions of the effective input utilization. Except from this, the efficiency increase can be caused also by the fact that the companies in the first phase had to invest and these initial costs were paid back after few years.

Figure 5–6 illustrate the TFP index development and its components according to the production orientation (companies exclusively oriented on crop production and animal breeding).

According to the graphical expression, it is evident that companies oriented on crop production reached greater deviations of the TFP development. Based on this, it is possible to state that these companies reached better results if there are the optimal climate conditions, in contrast to the sharp decline during the worsened conditions in comparison with the combined productive oriented companies. Even if companies oriented on crop production and animal breeding do not reach high increase of productivity and efficiency, they are able to significantly eliminate climate risks.

The area of cultivated land is another factor which is interesting to examine from the reason of the optimal area determination and agricultural companies competitiveness. Figures 7–9 illustrate the TFP index development and its components in companies divided according to the size.

The lowest variability was observed in companies which cultivated the area in the interval 1 000–2000 hectares. This group is also characterised by a stable increase in the technical efficiency change what indicates a faster pace of new technologies adaptation into the production process.

CONCLUSION

The differences in the terms of technological change and change of technical efficiency are important not only from the analytical point of view but also from the factors aspect which influence their origin. The change of technical efficiency could be interpreted as a relative measure of managerial abilities of input utilization under the given technological conditions. On the other side, technological change presents changes in labour productivity based on the changes in technologies and production processes. In a simplified way, we can state that positive changes in technical efficiency are the consequence of the increasing knowledge level and management experiences. Unlike the technical efficiency change, the technological change depends on a great measure on investments into new technologies and research (Ahmadet al. 1996).

The average TFP index value did not change during the analyzed period, however, certain fluctuations of the individual components of this indicator were observed. As the positive, we can mention the stabilization and gradual increase of the technical efficiency change. One of the reasons of short-term technical efficiency measure decrease is introduction of new technologies in higher range and in a short time. Vasavada and Chambers (1986) pointed out this fact in the USA agriculture when the introduction of new technologies caused costs on fitting mainly in cases when the farms structure is changing slowly. Further, we can state that no significant differences occurred among the analysed legal forms. No legal form reached such tendencies in the TFP index development which

will determine it as a dominant group of companies according to the productivity and efficiency long term development. Specialized producing orientation on crop production was impacted with significant changes in the productivity development as well as the combined companies according to the climate conditions change on which their total production depends. From this reason, it is necessary to think about the level of production process diversification which will be optimal to reach the constant growth of the firm's efficiency.

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