Technological heterogeneity, technical efficiency and subsidies in Czech agriculture

Technologická heterogenita, technická efektivnost a přímé platby v českém zemědělství

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Abstract

This paper deals with an analysis of technological heterogeneity and technical efficiency in individual sectors of Czech agriculture after the EU enlargement in 2004. A parametric approach was used – Stochastic Frontier Analysis (SFA) to address the research questions. Specifically, it is employed the Random Parameter Model specification, in which sector dummies are used to capture the intersectoral as well as intrasectoral differences in technology. The results show there is significant heterogeneity among the studied sectors (i.e., combined, plant, animal and other production). The analysis showed that Capital and Material are being substituted more and more for Labour in all sectors, especially in animal production. This result is to be expected, as the technology in this sector is labour-saving. However, it was found out that land elasticity is quite low in plant production and combined production; since Land is a production factor that significantly determines the level of final output, this result is quite strange. One possible explanation may be the policy of distributing subsidies among farmers, when the land is kept but used in a more extensive way. The intrasectoral differences in technology are statistically significant for all inputs. Average technical efficiency is highest in other production and lowest in animal production, while it is approximately at the same level in plant production and combined production. It was discovered that diversification (combined production) of activities lowers the level of technical efficiency compared to specialisation (plant production), but on the other hand it does allow for alleviation of the negative impacts of specialization (animal production) by optimizing the production program. Finally, the analysis did confirm a statistically significant positive relationship between SAPS subsidies and technical efficiency. Organic farming has a negative impact on technical efficiency and the influence of labour force quality is positive. The statistical significance of TOP UP subsidies as well as the localization of the company to LFA have not been proved.

Keywords: Czech agriculture, direct payments, stochastic frontier analysis, technical efficiency, technology

Abstrakt

Článek se zabývá analýzou technolocké heterogenity a technické efektivnosti jednotlivých sektorů českého zemědělství po vstupu České republiky do Evropské unie v roce 2004. Odpovědi na výzkumné otázky jsou hledány s využitím parametrického přístupu – analýzy stochatické hranice (SFA). Ve výzkumu byla aplikována specifikace modelu náhodných parametrů, do kterého jsou sektorové dummy proměnné zařazeny pro zohlednění intersektorových rozdílů v použité technologii. Výsledky ukazují na statisticky významnou heterogenitu mezi sledovanými sektory (tj. kombinovaná, rostlinná, živočišná a jiná produkce). Analýza prokázala, že práce je stále více nahrazována kapitálem a materiálem, a to ve všech sektorech – nejsignifikantněji pak v odvětví živočišné produkce. Tento výsledek je však očekávaný, jelikož technologie využívaná v daném sektoru je na práci úsporná. Dále bylo zjištěno, že v odvětví rostlinné a kombinované produkce je hodnota elasticity půdy oproti očekávání nízká – tento výsledek je zarážející, jelikož půda je produkční faktor významně determinující úroveň finální produkce. Jedním z možných vysvětlení je politika rozdělení podpor mezi farmáři, kdy půda je pak držena, avšak využívána spíše extensivním způsobem. Intrasektorové diference v technologii jsou statisticky významné ve všech sektorech pro všechny vstupy. Průměrná technická efektivnost dosahuje nejvyšší úrovně v odvětví ostatní produkce, zatímco nejnižší v odvětví živočišné produkce. Technická efektivnost odvětví rostlinné a kombinované produkce je na přibližně stejné úrovni. V rámci výzkumu bylo dále zjištěno, že diverzifikace aktivit (kombinovaná produkce) snižuje v porovnání se specializací (rostlinná produkce) úroveň technické efektivnosti. Na druhou stranu však umožňuje zmírnit negativní vliv specializace (živočišná produkce), a to optimalizací výrobního programu. V neposlední řadě analýza potvrdila statistickou významnost pozitivního vztahu mezi přímými platbami SAPS a technickou efektivností. Ekologické zemědělství má negativní vliv na technickou efektivnost a vliv motivace lidské práce je pozitivní. Statistická významnost přímých plateb TOP UP stejně tak jako lokalizace farmy v méně příznivých oblastech nebyla prokázána.

Klíčová slova: analýza stochastické hranice, české zemědělství, přímé platby, technická efektivnost, technologie

Introduction

It is already more than 10 years after the Czech Republic became a member of EU. The EU enlargement was a mammon task and was connected with huge expectations about the consequences of this institutional change. This was relevant to all segments of the Czech economy and to agriculture in particularly given the amount of expected subsidies, as well as strong competition from the common market. More than 10 years after the enlargement, it is time to evaluate the pros and cons of EU membership and address questions that were raised before the EU accession. This paper will be focused on Czech agriculture. The paper addresses the following three questions. The first question relates to technology. Since EU membership significantly increased the level of subsidies to Czech agriculture, it will be investigated whether this support was translated into improvements in technology. The second question concerns the development of technical efficiency. It will be investigated inter- and intrasectoral differences in the development of technical efficiency, including verification of the leapfrogging hypothesis and the identification of possible expected structural changes in the analyzed sectors. Finally, the relationship between the development of technical efficiency and subsidies is of special interest.

Productivity and efficiency as important factors determining the overall competitiveness of agricultural producers have received special attention in the European agricultural research in the last two decades (e.g. Ball et al., 2001; Brümmer et al., 2002; Bureau and Butault, 1992; Kleinhanß et al., 2007; Latruffe et al., 2012; Wijnands et al., 2008; Zhu and Lansink, 2010). The authors addressed research questions on adjustment processes connected with competitiveness, CAP changes and EU enlargement in old as well as new member countries. Moreover, the relation between technical efficiency and subsidies was studied e.g. in Hungary (Bakucs et al., 2006), Spain (Gaspar et al., 2009), Greece (Rezitis et al., 2003), France (Guyomard, 2006) and Ireland (O'Neill et al., 2002), among other places. The authors mostly found that direct payments negatively impacted the technical efficiency of farms. In addition, Chau and de Gorter (2005) and Väre (2007) point out that direct payments may affect a farmer's decision to remain or leave the sector. Due to EU subsidies, farmers may not have such a strong willingness to constantly improve the overall performance of their companies (Bergström, 2000; Ferjani, 2008). Furthermore, several studies dealing with the technical efficiency of farms include localisation (or soil characteristics) (e.g. Latruffe et al., 2004; Liu and Zhuang, 2000) as well as specialisation of the farm (e.g. Latruffe et al., 2005; O'Neill et al., 2002) as explanatory variables entering the model. With regard to the impact of LFA, Lambarraa and Kallas (2009), Zhu et al. (2008) and Madau (2010) found that LFA had a somewhat negative effect on the level of technical efficiency. Focusing on the Czech agriculture, the studies on efficiency includes e.g. Curtiss (2002), Čechura (2009, 2010, 2014), Čechura et al. (2015), Davidová and Latruffe (2003), Hřebíková and Čechura (2015), Jelínek (2006), Kroupová (2010), Mathijs et al. (1999) and Matulová (2013). The results indicate that technical efficiency is an important factor in determining the performance of Czech agriculture; however, due to the character of the data chosen and the method and/or specification of the model, the level of technical efficiency differs (Čechura, 2009).

The paper is organized as follows. Section Materials and methods presents the specification of theoretical model, presents the estimation strategy and introduces the data set; Section Results and discussion provides results of production frontier model, compares and discusses estimated technology, technological change and technical efficiency incl. its determinants. Section Conclusions contains a discussion and concluding remarks.

Materials and methods

Theoretical model and estimation strategy

To address the research questions it is introduced a novel model specification in which inter- and intrasectoral differences in technology as well as inter- and intrasector-specific technological change are captured.

Concerning the transformation process it is assumed that it can be well approximated by the translog production function model. That is, the deterministic part of the model can be written as:

$$\ln f(t, \mathbf{x}_{it}\ ;\boldsymbol{\beta}) = \sum_{j=1}^{K} \beta_j \ln x_{ijt} + \frac{1}{2}\sum_{j=1}^{K}\sum_{k=1}^{K} \beta_{jk} \ln x_{ijt} \ln x_{ikt}$$
$$\beta_t t + \beta_t t^2 + \sum_{j=1}^{K} \beta_{jt} \ln x_{ijt} t \quad , \qquad (1)$$

where x_{it} is a vector of inputs containing the production factors – Labour (A_{it}), Land (L_{it}), Capital (K_{it}) and Material (M_{it}). Indices i, where i = 1, 2,…, N, and t, where $t \in \tau(i)$, refer to a certain agricultural company and time, respectively, and $\tau(i)$ represents a subset of years T_i from the whole set of years T (1, 2,…T), for which the observations of the *i*-th agricultural company are in the data set (see unbalanced panel).

Moreover, it is assumed that the technical inefficiency is an important characteristic of the analyzed sample. That is, it is assumed that the production possibilities can be approximated by a frontier production function model:

$$lny_{it} = lna_0 + lnf(t, x_{it}; \beta) - u_{it} + v_{it} \quad , \qquad (2)$$

where lna_0 is an intercept (productivity parameter), u_{it} stands for the technical inefficiency term and v_{it} is the random error (statistical noise). For estimation, u_{it} and v_{it} have to be parameterized. It is assumed that the following distributional assumptions hold: $v_{it} \sim N(0,\sigma_v^2)$ and $u_{it} \sim N^+(\mu,\sigma_u^2)$. Moreover, it is assumed that u_{it} and v_{it} are distributed independently of each other and of the regressors.

In the analysis, the models belonging to the group of Random parameters model (RPM) (Greene, 2005) are used. The model selection is based on testing the more flexible form against the less flexible form. That is, the proper model specification is based on the LR test, and the following model specifications are tested: TREM (True Random Effect Model), RPM (Random Parameter Model), RPM with heterogeneity and RPM with heterogeneity and heteroscedasticity. The most flexible form is RPM with heterogeneity and heteroscedasticity. The other model specifications are nested within the last-mentioned.

Since RPM is a very flexible model specification, it allows for the definition of vector β as:

$$b_j = \beta_j + \Delta_\beta S_i + \mu_{i\beta}\ , \qquad (3)$$

where β_j represents the means of random parameters, $\Delta_\beta S_i$ is specified to capture intersectoral differences in technology, and $\mu_{i\beta}$ accounts for intrasectoral differences in technology. The intersectoral differences in technologies are captured by using sector dummies. That is, vector S_i contains sector dummy variables.

The heteroscedasticity in the most flexible model specification is controlled by using sector dummies, subsidies, a dummy for LFA, a dummy for organic farming and a variable representing the level of social costs in the distribution of u_{it}, in particular:

$$\sigma_d^2 = \sigma_u^2 e^{\sum_d s_d \gamma_d}, \quad (4)$$

where Sd is a vector containing the mentioned variables.

Strochastic frontier models are estimated by maximum simulated likelihood in the econometric software LIMDEP 9.0.

Data

The panel data set was drawn from the Albertina database. The database contains all registered companies and organizations in the Czech Republic. In this analysis, the final accounts of those companies whose main activity is agriculture, according to the NACE classification, is used. Since not all companies in the database have complete information, the database was cleaned as follows: for further analysis, only those companies having two or more final accounts in the CreditInfo database over the period 2004 – 2008 and positive, non-zero values for all variables of interest are used. Also, outliers for all variables were removed.

Thus, an unbalanced panel data set containing 1,228 companies with 4,663 observations was used, representing the period from 2004 to 2008 (i.e., 3.797 observations on average per agricultural enterprise).

Furthermore, using the State Agricultural Intervention Fund (SZIF) database, individual agricultural enterprises that were beneficiaries of specific subsidies – SAPS, TOP UP and LFA – were identified. The database LPIS was used to collect all information about the amount of agricultural land used for production owned by individual agricultural companies in the sample. This database contains data from 2004 onward.

To distinguish organic from conventional farming, the subjects registered as companies which exclusively use only organic farming principles were identified – for this reason the list of organic farmers provided by the Czech Ministry of Agriculture was used.

Finally, the price indices and regional wages were taken from the Czech Statistical Office (CZSO) database. The source of official land prices was a study by Němec et al. (2006).

Following variables in the model were used: Output, Labour, Land, Capital, Material, SAPS subsidies, TOP UP subsidies, an LFA dummy variable and sector dummy variables:

Output (y) is represented by total sales of goods, products and services and was deflated by the index of agricultural prices (2005=100).

Labour (A) input is total labour costs per company, divided by the average annual regional wage in agriculture (region = NUTS 3).

The total quantity of land employed in the production process (L) of a particular agricultural company is adjusted (multiplied) by the land quality (the land quality index is expressed as the ratio of the official land price of a given region to the maximum official regional price of land).

Capital (C) is represented by the book value of tangible assets and was deflated by the index of processing prices (2005=100).

Material (M) is represented by the total costs of material and energy consumption per company and was deflated by the index of processing prices (2005=100).

SAPS direct payments are represented by the amount of single area payments (SAPS), and TOP UP are represented by national additional payments (TOPUP). The localization of a company in LFA is represented by a dummy variable (D1). The identification of organic farmers is represented by a second dummy variable (D2). The sector dummy variables distinguish between plant production (S1), animal production (S2), combined production (S3) and other production (S4). Social costs represent the influence of labour force quality (SOCN).

All companies in the sample were split into four sectors according to their OKEČ classification (see Table 1).

Table 1. Sectors according to OKEČ classification

Tabulka 1. Sektory zemědělství na základě klasifikace OKEČ

Sector	OKEČ classification	No. of observations
Sector 1 – Plant production	01.1	391
Sector 2 – Animal production	01.2	141
Sector 3 – Combined production	01.3	4031
Sector 4 – Other production	01.4	100

Results and discussion

Model specification, heterogeneity in technology and technological change

First, it was tested whether more flexible formulations contribute to the explanatory power of the model. LR tests were employed and tested different model specifications – TREM, RPM, RPM with heterogeneity and RPM with heterogeneity and controlling for heteroscedasticity.

The LR test establishes that the more flexible a specification is, the better it represents the production structures of the analyzed agricultural companies. Thus it is concluded that the model with heterogeneity and heteroscedasticity is the most appropriate formulation.

Table 2 provides parameter estimates of the production function. Since all the variables are divided by its geometric mean, the fitted coefficients represent production elasticities. The results show that the fitted production elasticities are consistent with economic theory on the sample mean. That is, the elasticities satisfy the criterion of monotonicity, meaning they are all positive, as well as the criterion of quasi-concavity. Moreover, production elasticities are also consistent with the information in the dataset – the relationship of material and labour costs in production.

Table 2. Parameters estimate

Tabulka 2. Odhad parametrů modelu

First-order parameters			Second-order parameters		
Variable	Coefficient	P[│Z│>z]	Variable	Coefficient	P[│Z│>z]
Constant	0.1302***	0.0000	TT	-0.0382***	0.0000
Constant - Plant production	0.1364***	0.0000	AT	-0.0550***	0.0000
Constant - Animal production	-0.3849***	0.0000	LT	-0.0072	0.1977
Constant - Other production	0.0851	0.9995	KT	0.0076***	0.0050
Constant – scale	0.1499***	0.0000	VT	0.0346***	0.0000
A	0.1070***	0.0000	AA	0.0418***	0.0000
A - Plant production	0.0600***	0.0005	LL	-0.0271	0.3568
A - Animal production	-0.0362	0.1007	KK	0.0470***	0.0000
A - Other production	-0.0881***	0.0000	VV	0.0726***	0.0000
A – scale	0.0288***	0.0000	AL	0.0324***	0.0016
L	0.0724***	0.0000	AK	0.0104***	0.0070
L - Plant production	-0.1179***	0.0000	AV	-0.0572***	0.0000
L - Animal production	-0.4981***	0.0000	LK	0.0284***	0.0003
L - Other production	-0.6230***	0.0000	LV	-0.1712***	0.0000
L – scale	0.1546***	0.0000	KV	-0.0217***	0.0000
C	0.1157***	0.0000			
C - Plant production	0.0151	0.2522	suONE	6.3844***	0.0000
C - Animal production	0.1706***	0.0000	suS1	0.7845***	0.0000
C - Other production	0.1650***	0.0000	suS2	-0.0593	0.5716
C – scale	0.0133***	0.0000	suS4	-18.1784	1.0000
M	0.7427***	0.0000	suLSAPS	-0.3576***	0.0000
M - Plant production	-0.0931***	0.0000	suLTOPUP	-0.0337	0.1937
M - Animal production	-0.0076	0.6628	suD1	0.0363	0.3435
M - Other production	0.1328***	0.0000	suD2	1.2404***	0.0000
M – scale	0.1479***	0.0000	suSOCN	-0.1091***	0.0000
T	-0.0419***	0.0000	Sigma(v)	0.0738***	0.0000
T - Plant production	0.0129	0.1600			
T - Animal production	0.0039	0.7526			
T - Other production	0.0161**	0.0179			
T – scale	0.0096***	0.0000			

***, **, * denote significance at the 1%, 5%, and 10% level, respectively

It was estimated that both intersectoral and intrasectoral heterogeneity in technology are important phenomena which characterize Czech agriculture. As far as intersectoral heterogeneity is concerned, there are significant differences among sectors, especially in productivity parameters. Compared to the other sectors, Labour elasticity (A) is significantly lower in animal production and other production. This finding is to be expected, since the technology in animal production is labour-saving. The results for Capital elasticity (C) show the opposite trend. Compared to previous studies of Czech agriculture (e.g. Čechura, 2009), these results indicate an increase in intensity of capital inputs to total production. Thus, it is possible to conclude that farmers become more and more eligible to get bank loans, and also take greater advantage of the opportunity to draw investment subsidies. The estimated Material elasticity (M) of other production is the highest among the studied sectors, followed by animal production. The finding of animal production elasticity is to be expected, since the production in this sector is capital-using according to the character of its technological process. In addition, an analysis of the development of production elasticities showed that Capital and Material are being substituted more and more for Labour (this result is most significant in animal production). Land elasticity (L) differs among individual sectors. The intensity of land elasticity is significantly higher in other production and animal production. Furthermore, land elasticity has a negative level in these two sectors, evaluated on the sample mean. Since land is not considered an important production factor for all enterprises operating in animal production, this result is not examined in depth. On the other hand, for plant production and combined production the amount of land used (adjusted by its quality) needs to be taken into account as a factor, which significantly determines the level of final output. It is therefore unexpected that the land elasticity of these two sectors is quite low. The policy of subsidies distribution may be – inter alia – a possible explanation: it is possible to identify situations where land is kept by agricultural enterprises, but is used in a more extensive way (see, e.g. Matulová, 2013). Intrasectoral differences are important in all sectors for all inputs.

Technological change has a negative impact on production (by approximately 4.2 % per year) and accelerates with time, i.e., it is possible identify a technological regression that deepens over the studied period of 2004-2008. The hypothesis about the Hicks neutral technological change was rejected at a 5% level of significance. Technological change was Material- and Capital-using and Labour-saving (technological change was not statistically significant for the Land production factor). This supports the results discussed earlier about Capital and Material being substituted for Labour, and it is affected by the adoption of new capital-intensive technologies in the production process. On the other hand, the changes that occur as a consequence of technological progress negatively influence the final production of the agricultural sector. This could reveal some problematic issues of a primarily investment character (such as the wrong timing of an investment, incomplete use of new technology capacity and inadequacy of the investment type, among others). It may be also deduced that technological renewal has not yet been completed in some companies.

Intersectoral differences are only pronounced for combined production at a 1% level of significance. This suggests that technological regress is lower in combined production as compared to animal and plant production. Intrasectoral differences in technological change are statistically significant for all sectors. This implies the significance of intrasectoral heterogeneity in terms of technological change. Thus it is possible to conclude there are companies in the sample that can positively exploit ongoing technological change.

Estimated returns to scale show that, on average, agricultural companies operate with constant returns to scale (1.0063). As this result is mainly caused by the outputs of combined production, other sectors show decreasing returns to scale (see Table

3). These results imply the possible influence of diversification or specialization, as the case may be, on economies of scale.

Table 3. Returns to scale

Tabulka 3. Výnosy z rozsahu

Sector	Descriptive statistics of returns to scale				
	Mean	Std. dev.	Minimum	Maximum	No. of observations
Plant production	0.9475	0.1627	0.5872	1.5640	391
Animal production	0.7961	0.2550	0.3295	1.5303	141
Combined production	1.0283	0.1443	0.4997	2.0630	4,031
Other production	0.6822	0.1688	0.3401	1.2171	100
Total agriculture	1.0063	0.1657	0.3295	2.0630	4,663

Technical efficiency

Average technical efficiency in the studied sample is high (90.6 %). The kernel density function of the technical efficiency distribution (Figure 1) shows that most agricultural companies reach a level of technical efficiency higher than 80 %, and only a small percentage has a lower level of technical efficiency.

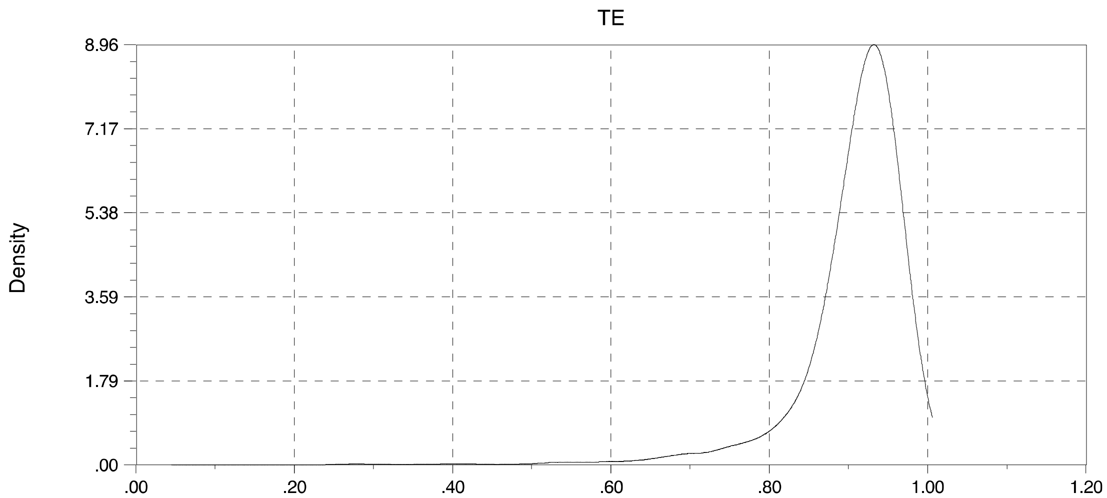

Figure 1. Kernel density distribution of technical efficiency

Obrázek 1. Kernelova hustota pravděpodobnosti technické efektivnosti

Also, the least and the most technically efficient agricultural companies were compared (10 % for each group was used) – see Table 4 for more details. The results show the difference in technical efficiency – 24 %, on average. Production elasticities are similar within these two groups; the only exception is Land elasticity. Land elasticity is about 0.11 percentage points higher for the less technically efficient group, indicating that less technically efficient agricultural companies become more dependent on provided subsidies which are linked to the amount of their land (namely SAPS and TOP UP subsidies).

Table 4. Technical efficiency and RTS

Tabulka 4. Technická efektivnost a výnosy z rozsahu

10 % of :	TE	Elasticity				Returns to scale
		Labour	Land	Capital	Material	
The least technically efficient companies	0.4795	0.1106	0.1728	0.0996	0.7623	1.1453
The most technically efficient companies	0.8856	0.1215	0.0670	0.1095	0.7329	1.0310

To analyse the influence of the size of the company (expressed by amount of land) on technical efficiency, the companies were split in the sample into 21 groups according to their hectare size (see Figure 2). The results lead to a general conclusion that technical efficiency grows with an increase in company size, and both standard deviation and relative variability decline. Furthermore, it was discovered that companies with more than 1,000 ha of land employed in the production process became more technically efficient (with an average technical efficiency of 91.76 %). It may be considered that those agricultural companies in the group with an amount of land between 1,100 and 1,200 ha (92.75 %) to be the most technically efficient. In addition, the number of companies with extreme values of technical efficiency decreases with an increase in size. In other words, larger agricultural companies (according to their cultivated land area) become closer in their technical efficiency within their group size, and therefore technical efficiency cannot be used as a source for gaining a competitive advantage within the group. This result is to be partially expected because companies that use more land in the production process should employ better (and also more capital intensive) technologies together with more automated processes, and thus also less human labour.

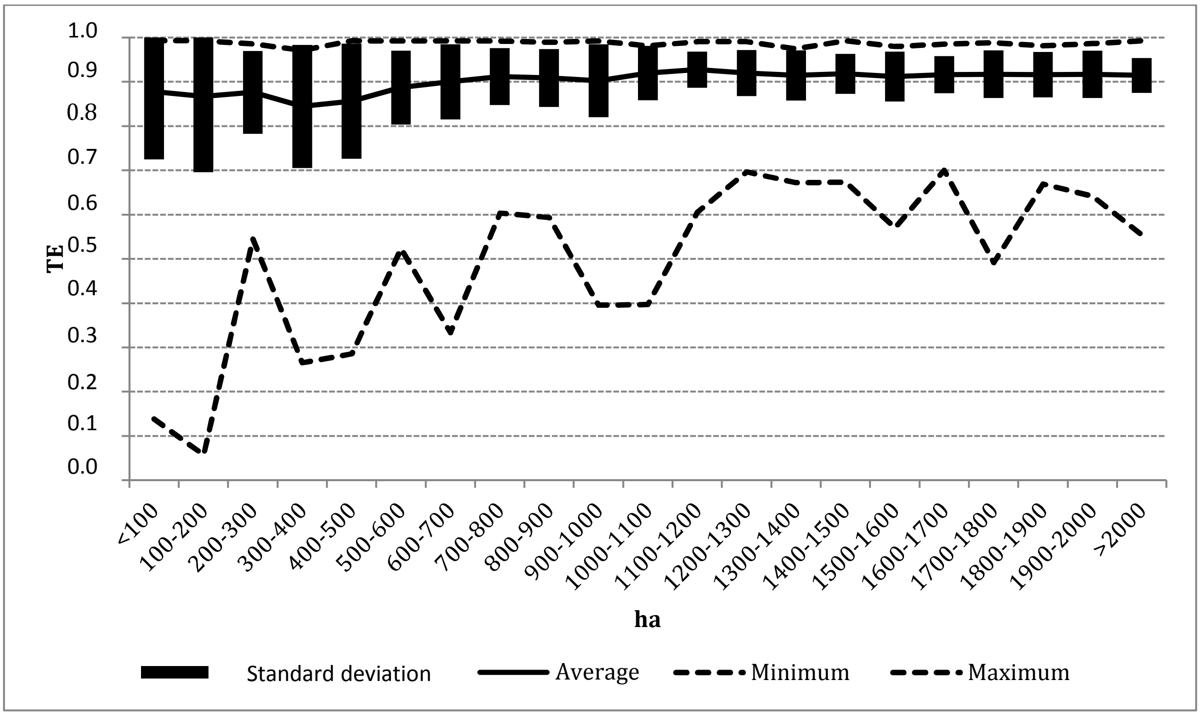

Figure 2. Technical efficiency and company size (ha)

Obrázek 2. Technická efektivnost a velikost farmy (v ha)

Table 5 provides descriptive statistics of technical efficiency for all sectors. The highest average for technical efficiency is reached in other production. On the other hand, the lowest average for technical efficiency was estimated for animal production, which suggests that strong competition in the meat market translates to lower technical efficiency, as a result of unused capacities, among other reasons (see Čechura, 2009). Average technical efficiency in plant and combined production is at approximately the same level. The high level of average technical efficiency, together with the low variability of technical efficiency in plant and combined production, suggests that technical efficiency is not an important source of the improvement of competitiveness in these sectors.

Table 5. Technical efficiency

Tabulka 5. Technická efektivnost

Sector	Descriptive statistics of technical efficiency				
	Mean	Std. Dev.	Minimum	Maximum	No. of observations
Plant production	0.9109	0.0874	0.2940	0.9907	391
Animal production	0.8338	0.1447	0.0576	0.9933	141
Combined production	0.9077	0.0705	0.1383	0.9933	4031
Other production	0.9201	0.0844	0.2809	0.9930	100

Figure 3 shows the development of technical efficiency in the studied sectors of Czech agriculture. From the given results it is clear that technical efficiency in all sectors shows the same trend in the period of 2004-2008, whereas it is quite unstable between individual years. There are a few possible reasons for this result – the influence of weather, ongoing processes of adjustment to new policies following the Czech Republic's accession to the European Union, the effect of received EU subsidies, and the influence of changes in domestic market competition (and related changes in the domestic demand for foodstuffs). Aside from these, we also need to keep in mind the influence of a delayed response in supply to demand for agricultural products.

According to the results obtained, it may be concluded that agricultural companies that specialize in plant production adapt better to new conditions related to the accession of the Czech Republic to the European Union. From an intersectoral point of view, this result implies that companies within this specialization have a higher level of competitiveness compared to others. On the contrary, the position of animal production on the domestic market declines, mainly as a consequence of the importation of meat products from other EU countries.

From Figure 3 it can be seen that some aspects related to technical efficiency are the same for all sectors, namely that the best agricultural companies (i.e., those with the highest level of technical efficiency) reach a high level of technical efficiency that does not significantly change over time. This conclusion is also valid for the average level of technical efficiency, with the exception of animal production. Furthermore, given the high level of average technical efficiency in all sectors, it can be said that companies take excellent advantage of their production possibilities. On the other hand, the development of minimum values of technical efficiency in individual sectors highlights the different strength and speed of ongoing structural changes related to the Czech Republic's accession to the European Union and adoption to new market conditions. As discussed by Čechura and Hockmann (2011) when evaluating the Czech food processing industry, a decrease in technical efficiency can indicate a slip in market position, while on the other hand, an increase in technical efficiency can be interpreted as the strengthening of a company's market power. This conclusion can also be reached for the agricultural sector. Given the high level of average technical efficiency, which is close to its maximum value in all studied sectors, it can be presumed that any decrease in competitiveness will lead to the overall reduction of a given sector

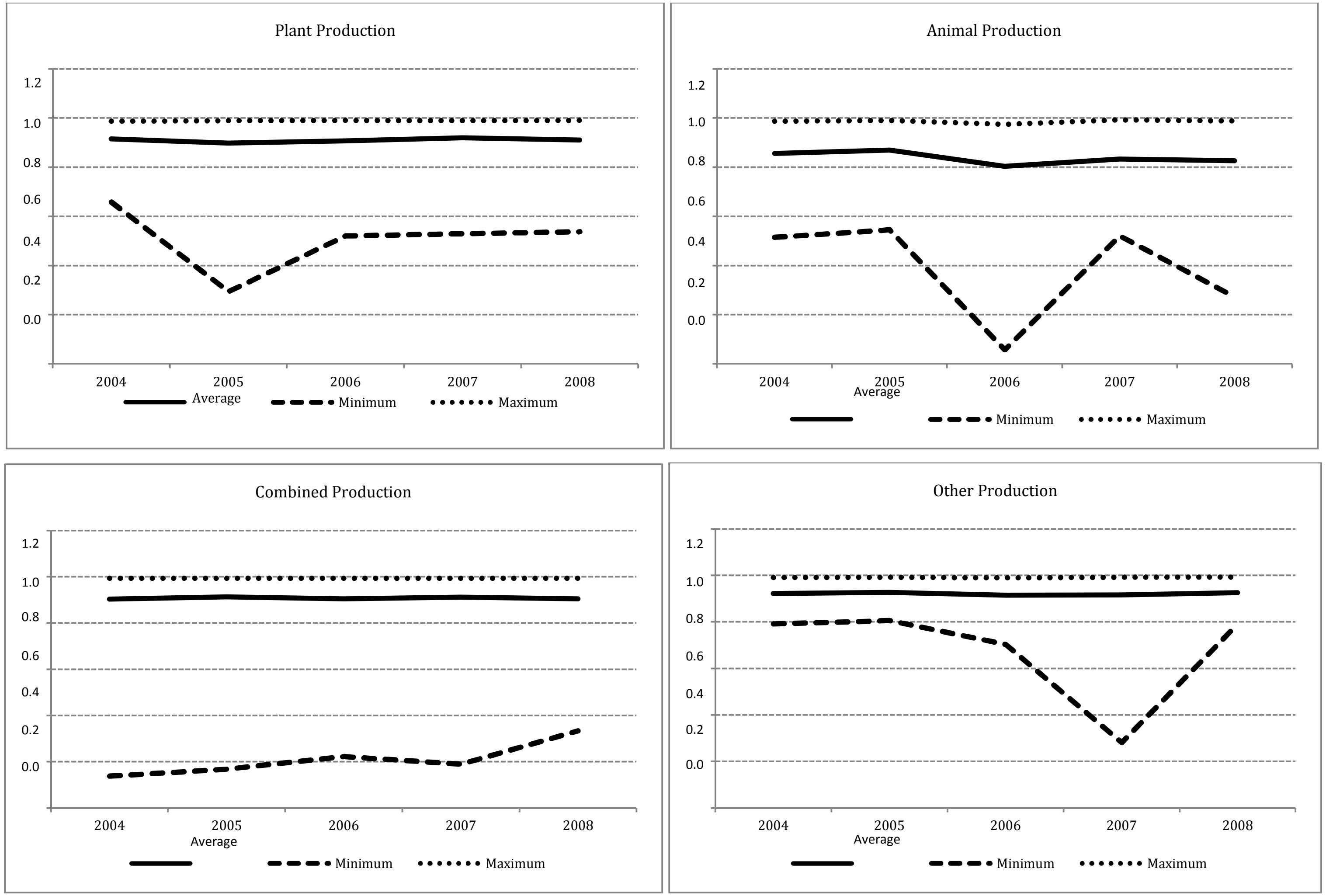

Figure 3. Development of technical efficiency in individual sectors of Czech agriculture

Obrázek 3. Vývoj technické efektivnosti v jednotlivých sektorech českého zemědělství

The development of average / maximum values together with the minimum values of technical efficiency allows us to draw some conclusions related to intrasectoral competitiveness. Some of the companies in animal production fall behind the best companies in that sector. This could imply that the adaptation of animal production to new market conditions has not yet finished. On the contrary, the position of companies in plant production seems to be quite stable over time; in other words, it cannot be identified any major structural changes in this sector. Combined production always “combines” the results of previously discussed sectors, and this is true now as well. From Figure 3, it is evident that combined production – as well as animal production – faced changes in market conditions following the Czech Republic’s accession to the European Union. Fortunately, possibly on account of easier change in the production process, companies in the combined sector coped better with these changes compared with animal production. Also, the diversification (in this case represented by combined production) allows for the alleviation of negative impacts of specialization (animal production) by optimizing the production program of companies in combined production (whereas it could be determined that animal production accounted for a greater share of the final output of combined production immediately following the Czech Republic’s accession to the European Union, for the remaining years in the studied period the opposite is true – it is evident that companies in combined production focus more on plant production.). This conclusion is supported by the nearly constant returns to scale shown by combined production. Owing to constant diversification of their activities, companies in combined production never reach as high a level of technical efficiency compared to those companies that specialize in plant production.

The question of stability of agricultural companies (Čechura and Hockmann, 2011) can be examined on the basis of Spearman’s rank correlation coefficients of technical efficiency (see Table 6). The results indicate that the order of the agricultural companies in all studied sectors is quite stable, and thus leapfrogging does not appear to be an actual issue of Czech agriculture. In other words, it can be said that as a result of structural changes the best performing companies (according to the average level of their technical efficiency) strengthen their position on the market, while the worst companies are falling behind. This is evident mainly in animal production.

Table 6. Spearman’s rank correlation coefficients of technical efficiency

Tabulka 6. Spearmanův koeficient korelace technické efektivnosti

Sector	2004/2005	2005/2006	2006/2007	2007/2008
Plant production	0.7626	0.7548	0.7761	0.6508
Animal production	0.6702	0.6789	0.9115	0.8933
Combined production	0.6793	0.7860	0.7224	0.7268
Other production	0.6569	0.7228	0.7874	0.6703

Finally, Table 2 provides the parameter estimate of the various factors determining technical efficiency (namely SAPS, TOP UP, and several dummy variables representing LFA (D1), organic farming (D2) and the analysed sectors – plant production (S1), animal production (S2) and other production (S4), and finally the influence of the quality of human labour (SOCN). The results show there is no statistically significant relationship between technical efficiency and TOP UP subsidies. However, it is estimated that SAPS subsidies decrease the level of technical inefficiency. This suggests that there is a qualitative difference between the subsidies SAPS and TOP UP. Even though there is no statistically significant relationship between technical efficiency and the localization of the company to the LFA, in-depth analysis showed that companies located in less favoured areas reach a higher level of final output, on average, compared to the second group of companies located outside of LFA. This is true despite the preference for a rather extensive method of farming held by companies located in the LFA. The main reason for this can be seen in the greater amount of subsidies targeted toward these companies. Both marginal areas and the second discussed group have approximately the same level of technical efficiency, implying the result that the given subsidies are put to more efficient use by agricultural companies located in the LFA. A comparison of conventional farming and organic farming proves that organic farming has a lower level of technical efficiency. As suggested by Kroupová (2010), among others, this is also caused by other subsidies being targeted to this sector of agriculture. Given the significantly higher level of Land production elasticity for organic farmers, the conclusion may be that these companies are much more dependent on subsidies provided from public resources. The assumption by agricultural companies about Social costs serving to express the level of ability of employees' motivation and a related increase in labour force quality, which positively influences technical efficiency, is supported by the results. Thus, the conclusion is that agricultural companies that provide company benefits do not waste their resources. That is, it was found that providing the benefits is an important issue for agricultural companies, as almost 80 % of the companies in the sample provide them. Finally, the coefficients on sector dummies suggest that the level of technical efficiency in animal production is at approximately the same level as in combined production. However, plant production has a higher level of technical efficiency as compared to other sectors.

Conclusions

The analysis shows that there is significant heterogeneity within and among the studied sectors – combined production, plant production, animal production and other production. The analysis proved that Capital and Material are being substituted more and more for Labour in all sectors, most significantly in animal production. This result is to be expected because the technology in this sector is labour-saving. However, it was found out that land elasticity is quite low in plant production and combined production – since it is considered Land to be a production factor which significantly determines the level of final output, this result is quite strange. One possible explanation could be the policy of subsidies distribution among farmers, where the land is kept but used in a more extensive way.

Technological change has a negative impact on production; moreover, it accelerates with time. When technological change is Material- and Capital-using and Labour-saving (technological change was not statistically significant for the Land production factor), it may be assumed it is affected by the adoption of new capital-intensive technologies in the production process. On the other hand, the analysis also identified some problematic issues connected to the negative influence of technological progress on final production. This could be caused by problems of an investment character, or because technological renewal has not yet finished, among other reasons.

A technical efficiency analysis shows that there are notable differences between the companies. Average technical efficiency in plant and combined production was at approximately the same level, while animal production reached the lowest values the other production had the highest value. This could be connected to unused capacities and strong competition in the meat market. It may be presumed that companies in both plant and combined production do not take technical efficiency into account as one of the sources of their improvement in competitiveness. An in-depth analysis also showed that diversification of activities (i.e., combined production in this case) lowers the level of technical efficiency compared to specialization (i.e., plant production), while on the other hand it allows for alleviation of the negative impacts of specialization (i.e., animal production) by optimizing the company's production program.

As far as direct payments are concerned, the analysis did not confirm any statistically significant relationship between TOP UP subsidies and technical efficiency. On the other hand, the estimation shows that technical efficiency can be increased by SAPS subsidies. This suggests that there is a qualitative difference between the subsidies SAPS and TOP UP. The results show there is no statistically significant relationship between technical efficiency and the localisation of the company to the LFA. Moreover, organic farming has a negative impact on technical efficiency and labour force quality positive.

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