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Farms Productivity Developments Based on Malmquist Production Indices

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Abstract

The aim of the article was to evaluate production efficiency changes of agricultural enterprises specialized in livestock production and identify its determinants. The total factor productivity (TFP) was used to analyse the changes as determined by the DEA Malmquist index. Evaluated sample contained panel data of 440 farms (114 organic and 326 conventional) based on FADN survey in the period 2011 - 2015. The results showed very little difference in technical efficiency between groups and relatively negligible changes over the time. About 69% of organic farms reached the productivity growth with the change in TFP of 3.17%. A total of 59% of conventional farms were managed with increasing productivity and the TFP change by 1.48%. Differences between groups were given mainly by Utilized agricultural area per farm, level of Total production, Livestock output, sum of Current subsidies per hectare, and by FNVA / AWU.

Keywords

Crop and animal production, efficiency, total factor productivity, organic and conventional farming.

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Introduction

Organic farming became an integral part of current agriculture. Widespread interest in ecology, clean environment, sustainable agriculture, and healthy life style supports the expansion of this farming system. Organic farming involves a lot of non-economic factors such as higher care of environment, more favourable agronomy techniques, landscape cultivation, animal welfare, social ties, and other socio-economic factors in comparison to conventional practices focused on high production.

Productivity of organic farms is generally lower than in case of the conventional farms. Reaching economic efficiency in organic farming is more complicated due to production process and market process specificities (Brožová and Vaněk, 2013). Differences between organic and conventional productivity and farming system were detailed reviewed by Nemes (2009). Some researchers argue about the effective reasonableness of the comparison of organic and conventional farming because of so different farming procedures and principal goal of agricultural system. With respect to this, conventional farming could be considered as the most widespread production system which include a mix of agronomic techniques. Some of them are quite similar to the organic ones and therefore the result of farming could be comparable (Cisilino and Madau, 2007). The best way to minimize incorrectness in analysis is accurate selection of comparative sample. It is suggested to compare farm groups with similar characteristics as far as farm type (arable, dairy, mixed, etc.), productive system, environmental conditions (land fertility, climate, etc.), same localization (Region), equipment of productive factors, and socio-economic conditions (Cisilino and Madau, 2007). Technological and management differences are another kind of criteria (Nemes, 2009). Organic farms are able to compensate their technical disadvantage (e.g. lower productivity) due to a more reasonable use of their own inputs rather than from enhancing productivity. Although the organic farms show better efficiency than conventional ones, their overall efficiency is not completely satisfactory (Cisilino and Madau, 2007).

Effectivity of farming in selected groups of farms can be compared by different ways. Farrell (1957) developed the concept of technical efficiency (TE) of farms based on the relationship between inputs and outputs. Differences in economic efficiency among groups of farms may result from variations in technical efficiency (larger output with equal amounts of inputs) or price efficiency (higher profits). This crucial method enabled the development of different more detailed analytic models. Data Envelopment Analysis (DEA) model is often used to evaluate results of farming productivity and calculate a value of their technical efficiency. The DEA method uses production units. Units with the highest efficiency are located on the efficient frontier. The method provides a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier (Špička, 2014). All farms involved in analysis are compared with only the "best" producers (Heidari et al., 2011). The technical efficiency score divides the sample (farms) into two groups – efficient with TE = 1.0 and inefficient with TE < 1.0. The statistical procedure tests differences of structural and economic indicators between two groups (Špička, 2014). Technical efficiency of farm is related to the subjects with the best results of analysed group, but it differs from the rate of farm profitability. Nevertheless, positive correlation between technical efficiency and profitability of production was proved (Boudný et al., 2011). The DEA method is suitable for groups of farms with similar value of inputs and outputs farming in similar productive and climatic conditions. Farms can be separated into more homogenic sub-samples according to the specialization, environment conditions and used technologies (Boudný et al., 2011). Development of farm productivity over a selected period can be evaluated by the Malquist index (Špička and Machek, 2015).

The DEA model divides evaluated sample of farms in two groups according to their technical efficiency. Several papers searched for factors describing the difference between successful and less successful subjects (Boudný et al., 2011; Davidova and Latruffe, 2003; Balcombe et al., 2005; Bravo-Ureta et al., 2007; Latruffe et al., 2008; Špička, 2014; Čechura et al., 2015; Madau, 2015; Medonos et al., 2015; Špička and Machek, 2015; and many others). The significant economic measures of production intensity in mixed type of farming are usually crop output per hectare, livestock output per livestock unit, productivity of energy and capital (Špička, 2014).

Change in total factor productivity (TFP) is significantly determined by the technological change (TCH) for all sectors of agriculture (type of farming). Čechura et al. (2015) analysed changes in TFP of Czech farms in 2007 – 2011. Sample included farms of cereal production, dairy production, and pork production. Technical/technological change was generally speeded up by the increase in subsidies and decrease in average costs. The successful farms specialized in dairy or pork production were also characterized by a high share of the crop production. Diversification of the production can minimize the production risks and the production of its own feed can minimize costs (Čechura et al., 2015). Livestock farms generally achieve significantly higher total technical efficiency than farms specialized in crop production (Boudný et al., 2011; Bravo-Ureta et al., 2007). This could be related to relatively homogenous methods of production in livestock, which are less dependent on human error, weather or climatic conditions than crop production. The best results of total technical efficiency were found in dairy production, cattle fattening, poultry fattening, and pork production (Boudný et al., 2011). The farming intensity is another key determinant of the technical efficiency. More extensive farms and regions have a lower technical efficiency than the more intensive ones (Špička, 2014).

One of the significant sources of agricultural data is FADN (Farm Accountancy Data Network) database. It involves information from all EU member states including the Czech Republic. FADN data include heterogenous subjects of conventional and organic farming. The best solution for analysing would be to consider a constant sample of farms introduced as a panel data (Cisilino and Madau, 2007). Several papers published results calculated from this database. Davidova and Latruffe (2003) or Latruffe et al. (2008) used DEA output-orientated model to analyse the efficiency of 88 livestock and 256 crop farms of the Czech FADN database.

Balcombe et al. (2005), Bravo-Ureta et al. (2007) or Madau (2015) compared technical and scale efficiency using both Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). Empirical findings suggest that the greater portion of overall inefficiency in the sample might depend on producing below the production frontier than on operating under an inefficient scale. Estimated technical efficiency from SFA model is substantially at the same level of this estimated from DEA model, whereas the scale efficiency arisen from SFA is larger than this obtained from DEA analysis (Madau, 2015).

Czech FADN database contains farms of conventional as well as organic farming.

Moreover, it includes farms of different types of farming. Livestock production is the most important part of organic farming in our republic. Based on the published papers, the aim of our research was to evaluate production efficiency changes of agricultural enterprises in livestock production and identify its determinants. The total factor productivity (TFP) was used to analyse the changes as determined by the DEA Malmquist index.

Material and methods

The FADN CZ provides structural and economic data in standard results. The complete panel data from the period 2011-2015 were available for 440 farms: 114 organic and 326 conventional. The analysis focused on farming with livestock (general codes 4,7,8 in TF8 FADN grouping). Table 1 gives information about number of analysed organic and conventional farms according to the type of farming.

Productivity measurement is often carried out from two perspectives, Standard CRS (constant return to scale) and VRS (variable return to scale) DEA models that involve the calculation of technical and scale efficiencies (TE) and the total factor productivity (TFP) which takes into account all possible inputs and outputs of an industry (firm, process). The second deals with the use of the Malmquist index to quantify the change in a farm's efficiency over a period of time (Coelli, 1996). All indices are relative to the previous year, so the output begins with the second year. There are five indices for each farm and period: Technical efficiency change relative to a CRS technology (effch), Technological change (techch), Pure efficiency change relative to VRS technology (pech), Scale efficiency change (sech) and Total factor productivity change (tfpch). The results distinguish among the farms with productivity growth (tfpch > 1) and decline in productivity (tfpch < 1).

The standard approach to the measurement of productivity change over the time is the Malmquist TFP index (Caves et al., 1982; Fare et al., 1994). The Malmquist index is a geometric mean of two indices, evaluated with respect to period s (the base period) and period t technologies (Fare et al., 1994).

$$M_O(y_s,x_s,y_t,x_t) = \left[\frac{d_O^s\ (y_t,x_t)}{d_O^s\ (y_s,x_s)}\right] \cdot \left[\frac{d_O^t\ (y_t,x_t)}{d_O^t\ (y_s,x_s)}\right]^{½} \quad (1)$$

For output orientation: MO > 1 → Productivity growth, MO < 1 → Productivity decline

Decomposition of the index into efficiency change and technological change:

$$M_O(y_s,x_s,y_t,x_t) = \frac{d_O^t\ (y_t,x_t)}{d_O^s\ (y_s,x_s)} \left[\frac{d_O^s\ (y_t,x_t)}{d_O^t\ (y_t,x_t)}\right] \cdot \left[\frac{d_O^s\ (y_s,x_s)}{d_O^t\ (y_s,x_s)}\right]^{½} \quad (2)$$

Further decomposition of the index efficiency change into pure efficiency change

$$\text{Pure efficiency change} = \frac{d_{O\,VRS}^t\ (y_t,x_t)}{d_{O\,VRS}^s\ (y_s,x_s)} \quad (3)$$

and scale efficiency change =

$$\left[\frac{d_{O\,VRS}^t\ (y_t,x_t)/d_{O\,CRS}^t\ (y_t,x_t)}{d_{O\,VRS}^t\ (y_s,x_s)/d_{O\,CRS}^t\ (y_s,x_s)} \cdot \frac{d_{O\,VRS}^s\ (y_t,x_t)/d_{O\,CRS}^s\ (y_t,x_t)}{d_{O\,VRS}^s\ (y_s,x_s)/d_{O\,CRS}^s\ (y_s,x_s)}\right]^{½} \quad (4)$$

Four inputs and three outputs were used for the efficiency calculation in our analysis. Indicators are related to the following FADN standard results codes: Total output (SE131), Crop

Type of farming	Number of farms	(AWU/100 ha)	UUA (ha/farm)	Livestock units (LU/100 ha)
Total	**440**	**3.53**	**757.21**	**58.76**
Organic farming	**114**	**2.83**	**242.32**	**49.97**
(45) Specialist dairying	14	3.70	205.01	68.15
(46, 47) Cattle	72	2.30	317.33	49.20
(48) Sheep, goats and other grazing livestock	17	3.94	68.14	42.01
(7, 8) Mixed livestock, crops	11	3.51	67.94	44.21
Conventional farming	**326**	**3.77**	**937.26**	**61.84**
(45) Specialist dairying	92	4.65	606.46	74.60
(46, 47) Cattle	28	3.31	291.50	63.99
(48) Sheep, goats and other grazing livestock	3	2.42	66.48	60.32
(7, 8) Mixed livestock, crops	203	3.46	1189.12	55.78

Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 1: Types of farming and number of farms represented organic and conventional groups.

output (SE135), Livestock output (SE206); Land input (SE025 - Total Utilized agricultural area), Livestock input (SE080 - Total Livestock unit), Labour input (SE010 - AWU), and Intermediate consumption (SE275 = SE281 Specific costs + SE336 Farming overheads). DEAP 2.1 program (Coelli, 1996) was used to measure the productivity indexes. The output-oriented Data Envelopment Analysis model assumed variable returns to scale. Variables were not deflated.

Statistical procedures for assessment of differences between efficient and inefficient groups were selected depending on the features of the two groups. If the two sample sizes are approximately equal, the equal-variance t-test can be used. The results of DEA indicate 169 farms with decline and 271 farms with growth, so the two-sample t-test compares the distribution between the farms with negative (group A) and positive (group B) change of efficiency. The null and alternative hypotheses were: H0: mean μ_1 = mean μ_2, HA: mean μ_1 > mean μ_2 (Diff > 0) or mean μ_1 < mean μ_2 (Diff < 0). So, the one-sided test of hypotheses is applied depending on the subjective assumptions about the efficiency determinants. The statistical analysis was processed automatically by software STATISTICA 12. Table 2 contains basic descriptive statistics of farms.

Results and discussion

Development of evaluated farms in 2011 - 2015

The results of DEA and TFP calculations are summarize in this section. We used balanced panel data for the period 2011 - 2015 with about 2,200 observations for 440 farms representing enterprises with livestock production (114 organic farms and 326 conventional farms). As the results from DEA Malmquist, we calculated measures of Efficiency change (effch), Technological change (techch), Pure efficiency change (pech), Scale efficiency change (sech), and Total factor productivity change (tfpch) for each farm. Average technical efficiency scores are presented in Table 3.

Based on DEA Malmquist analysis, overall improvement of productivity occurred in the group of complete panel data in the period from 2011 to 2015. A positive change in Total factor productivity enhanced by 1.92%. Technical efficiency in conditions of Constant returns to scale (effch) decreased by 1.07%, Technical efficiency (techch) increased by 1.66%, Technical efficiency of variable returns to scale (Pure technical efficiency; pech) lowered by 0.62%, and Scale efficiency change (sech) decreased by 0.45%. Development of Productivity change in individual years is presented in table 3. General improvement

Variable (per farm)	Mean	Standard deviation	Min	Max
Labor input	23.07	28.48	0.75	163.40
Utilized agricultural area	757.21	865.46	1.67	4 588.29
Livestock unit	398.38	465.43	4.29	2 348.29
Intermediate consumption	23 345 674	31 289 613	110 200	188 811 801
Total output (CZK)	30 832 699	42 700 716	143 000	302 363 000
Crop production (CZK)	13 899 283	21 265 079	20 000	216 540 000
Livestock output (CZK)	13 935 464	18 317 040	-491 000	90 510 000
Economic Size Class (1-14)	9	3.22	4	14

Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 2: Basic descriptive statistics of average farms in 2011-2015 (N = 440).

	Period	effch	techch	pech	sech	tfpch
2	2012/2011	1.000	1.013	1.012	0.989	1.043
3	2013/2012	1.005	0.999	1.001	1.005	1.016
4	2014/2013	0.987	1.037	0.983	1.003	1.079
5	2015/2014	0.928	1.018	0.98	0.985	0.983
	Geometric mean	0.989	1.017	0.994	0.995	1.019
	Number of periods with decline	effch<1=2	techch<1=1	pech<1=2	sech<1=2	tfpch<1=1; 169 farms
	Number of periods with growth	effch>1=1	techch>1=3	pech>1=2	sech>1=2	tfpch>1=3; 271 farms

Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 3: Malmquist Index summary of annual means.

was found in the period 2011 – 2014. In contrast, a decrease of 1.72% was calculated in the fifth year (2015/2014). The year 2014 was extremely successful from agricultural point with high yields of most crops. Decrease of productivity is corollary of subsequent comparison to usual agricultural production in 2015.

Productivity change by farming system categories

To compare the productivity change according to the farming system, i.e. organic and conventional, farms were separated into two groups. The Table 4 presents productivity change in groups of organic and conventional farms.

The group of organic farms (69%; 79 from 114 farms) showed running improvement of total productivity by 3.17% mainly due to Technical (technological) efficiencies with growth of 2% in the period 2011 – 2015. The highest increase was determined in comparison of 2013 and 2014 due to bumper yield in 2014. The harvest in 2015 was generally lower than in 2014, but still rather high. The favourable weather helped to gain sufficient yield which provided comparable factor of productivity in this group of farms as the previous year. A total of 59% of conventional farms (192 from sample of 326 farms) improved the efficiency and their development increased by 1.48% in the referenced period. Productivity continually increased from 2011 to 2014 and consequently decreased as was described for total set of farms due to general decrease of yield. Despite lower total value of farm production interpreted in CZK per hectare or farm unit, organic farms managed to reach higher change of technical productivity than conventional farms which testify for better adaptability of organic agriculture and ability to enhance its productivity. Farm production is limited by the farming system based on more environmental friendly practices.

Production of organic and conventional farms

Total factor productivity enabled to divide farms to separate groups based on their productivity development during the time. Farms with productivity index higher than 1 showed positive development (tfpch+). On the other hand, farms with index lower than 1 are described as subjects with negative change of efficiency (tfpch-). Table 5 presents production characteristics according to the FADN indicators of Standard results.

Organic farms showed better ability of positive improvement than conventional farms. Number of organic subjects with positive productivity index counted in our sample more than double of enterprises with negative change of efficiency. Compared to this, number of conventional farms with positive development exceeded number of farms getting worse just by 43%. Generally, there are about 20% of farms with positive technical efficiency in evaluated samples (Boudný et al., 2011; Balcombe et al., 2005; Heidari et al., 2011). The highest technical efficiency is usually reached in farms specialized in crop production (about 30%), whilst farms of livestock production or combined production improved only in 20% of analysed subjects. Combination of production types generally lower technical efficiency and variability of effectivity, as well (Boudný et al., 2011).

One of the first criteria usually used to describe farm characteristics is utilized agricultural area. Organic farms with positive index of productivity made use of larger area than farms with negative index as well as conventional farms. Utilized land area was relatively stable in organic farming, whereas conventional enterprises gradually decreased their area during the time.

Labour force in agriculture continually decreases.

Malmquist indices		effch	techch	pech	sech	tfpch	effch	techch	pech	sech	tfpch
Period		organic farming (N = 114)					conventional farming (N = 236)				
2	2012/2011	0.995	1.018	1.000	0.995	1.043	1.002	1.011	1.016	0.986	1.043
3	2013/2012	1.016	0.989	1.022	0.995	1.016	1.002	1.003	0.993	1.009	1.016
4	2014/2013	0.965	1.053	0.956	1.010	1.055	0.994	1.032	0.993	1.001	1.087
5	2015/2014	0.982	1.023	0.980	1.002	1.012	0.901	1.017	0.98	0.979	0.976
Geometric mean		0.989	1.02	0.989	1.000	1.032	0.989	1.015	0.995	0.994	1.015
the number of farms with decline		71	2	70	71	35	227	25	180	203	134
the number of farms with growth		43	112	44	43	79	99	301	146	123	192

Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 4: Malmquist index summary of organic and conventional farming groups.

	SE010 /100 ha	SE025 (ha /farm)	SE131 (CZK /ha)	SE135 (CZK /ha)	SE206 (CZK /LU)	SE131 / SE010 (thous. CZK /AWU)	SE275 /SE025 (CZK /ha)	SE275 /SE080 (CZK /LU)	SE131 /(SE270 - SE 370) (CZK /CZK)	SE605 (CZK /ha)	SE622 (CZK /ha)	SE621 (CZK /ha)	SE415/ SE0205 (CZK /ha)	SE415 / SE010 thous. CZK/ AWU)
Total	**3.53**	**757**	**32 995**	**13 418**	**28 865**	**1 045**	**24 862**	**46 329**	**1.11**	**11 280**	**1 406**	**1 973**	**14 766**	**500**
Organic farms														
total	**2.83**	**242**	**15 535**	**4 755**	**18 305**	**596**	**13 802**	**30 107**	**1.56**	**14 667**	**2 694**	**5 083**	**11 946**	**540**
tfpch-	**2.80**	**179**	**13 679**	**4 934**	**14 771**	**551**	**13 324**	**28 961**	**1.60**	**14 458**	**2 715**	**4 986**	**10 491**	**497**
2011	2.88	180	14 408	**5 433**	15 753	585	13 299	29 000	1.46	13 653	2 749	5 120	10 331	**496**
2012	2.95	179	14 634	**5 054**	15 440	569	13 501	28 281	1.60	14 651	2 827	5 099	11 412	**539**
2013	2.81	179	14 413	**5 121**	15 277	584	13 673	29 190	1.52	14 611	2 795	5 050	11 091	**517**
2014	2.72	177	13 700	**4 930**	14 649	566	13 544	29 863	1.59	15 177	3 044	4 745	10 881	**536**
2015	2.63	183	11 240	**4 132**	12 737	451	12 601	28 472	1.84	14 198	2 159	4 914	8 739	**397**
tfpch+	**2.85**	**270**	**16 358**	**4 675**	**19 871**	**616**	**14 015**	**30 615**	**1.54**	**14 760**	**2 685**	**5 126**	**12 590**	**559**
2011	2.72	271	14 244	**4 432**	16 893	561	12 805	28 667	1.64	14 158	2 783	5 363	11 226	**528**
2012	2.74	273	14 814	**4 553**	18 256	579	13 230	30 318	1.63	14 560	2 771	5 049	11 772	**542**
2013	2.76	274	15 163	**4 490**	19 816	583	13 346	30 473	1.58	14 612	2 774	4 976	12 030	**546**
2014	2.91	273	17 456	**4 911**	21 246	649	14 591	31 461	1.48	15 423	3 023	4 934	13 763	**592**
2015	3.10	260	20 112	**4 988**	23 143	705	16 101	32 155	1.37	15 049	2 072	5 310	14 160	**586**
Conventional farms														
total	**3.77**	**937**	**39 100**	**16 447**	**32 557**	**1 203**	**28 729**	**52 002**	**0.95**	**10 096**	**956**	**885**	**15 752**	**486**
tfpch-	**3.83**	**771**	**37 539**	**15 436**	**31 380**	**1 134**	**27 592**	**47 255**	**0.96**	**10 055**	**1 092**	**1 003**	**15 389**	**470**
2011	3.87	783	36 693	**15 177**	30 386	1 089	26 089	43 868	0.91	8 916	1 054	1 072	15 302	**450**
2012	3.86	778	37 731	**15 762**	30 283	1 127	27 155	45 362	0.92	9 163	1 104	1 039	15 347	**459**
2013	3.82	774	37 587	**15 150**	32 269	1 119	27 333	46 980	0.95	10 219	1 077	1 004	15 857	**475**
2014	3.83	766	40 136	**16 468**	34 081	1 215	29 154	50 555	0.95	10 991	1 191	940	17 191	**525**
2015	3.75	756	35 549	**14 625**	29 881	1 118	28 231	49 511	1.06	10 988	1 034	961	13 251	**438**
tfpch+	**3.74**	**1 053**	**40 190**	**17 153**	**33 379**	**1 250**	**29 523**	**55 314**	**0.95**	**10 124**	**861**	**802**	**16 006**	**498**
2011	3.67	1 066	35 456	**15 931**	30 396	1 110	26 371	50 219	0.95	8 543	847	857	13 516	**427**
2012	3.77	1 066	38 262	**16 855**	31 310	1 178	28 067	53 014	0.94	8 753	869	805	14 537	**448**
2013	3.72	1 053	39 254	**16 682**	34 351	1 217	29 117	54 614	0.96	10 501	861	785	15 846	**496**
2014	3.68	1 043	44 668	**18 581**	36 922	1 411	32 008	60 592	0.92	11 377	931	766	18 990	**599**
2015	3.84	1 037	43 313	**17 716**	33 915	1 337	32 050	58 130	0.97	11 449	797	799	17 140	**522**

Note: SE010 Total labour input (Annual Working Units), SE025 Utilized Agricultural Area, SE131 Total output, SE135 Crop output, SE206 Livestock output, SE275 Total intermediate consumption, SE270-SE370 Total output excl. wages, SE360 Depreciation, SE405 Investment subsidies, SE605 Total subsidies excl. on investment, SE632 SAPS, SE622 LFA, SE621 AEO, SE415 Farm net value added (FNVA)
Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 5: Production characteristics of organic and conventional farms in 2011 - 2015.

The analysis results confirmed faster decrease of labour input of conventional farms than of organic farming. Successful organic farms enhanced number of work force while group with negative index lowered. Labour input of organic farms was lower than conventional one.

Group of farms selected for presented analysis is focused on livestock production therefore the total production (total output) is created predominantly by livestock output. Total production and crop production are calculated in CZK per hectare, whereas livestock production is expressed in CZK per livestock unit (LU) with higher concise value in this point. Conventional farms continually increased total production in both groups of change of efficiency till 2014 with subsequent decrease. Successful organic farms gained gradually increased total output, whereas farms with negative efficiency enhanced production till 2013 followed by rapid decrease. Total output of organic farms with positive total factor productivity change (tfpch) counted in average 41% of total output of successful conventional ones. The rate changed from 40.2% in 2011 to 46.4% in 2015. Key role played difference in livestock production which changed by 13% between start and final of examined period. Based on the specialization of investigated farms, the main part of crop production are forage crops. Organic farms prefer production of own feedstuff and are less dependent on market swings. Conventional farms showed higher fluctuation in plant production among years of study resulting from differences in yield and market prices.

Total intermediate consumption of organic farms represents in average 87% of total output per hectare. The same characteristic of conventional farms average out 73.5% which confirms narrower funds turnover inside of organic farming. Total intermediate consumption includes total specific costs (SE281) and total farming overheads (SE336).

Sum of subsidies is an integral part of farming profitability. The value of total subsidies excluding on investment, increased during the time in organic farming as well as in conventional farming. The peak was reached in 2014 followed by decrease of SAPS and LFA rates in 2015. The system of environmental subsidies was changed, as well. Table 5 shows only chosen important subsidies from the whole budget, it is obvious that conventional farms with positive TFP change had lower LFA and AEO subsidies than conventional farms with negative TFP change due to different farming conditions where most of the land is outside LFA with a smaller proportion of grassland.

Criteria of Farm net value added (FNVA) per hectare or AWU is usually used as the most comparable characteristics. This parameter of farms with positive total factor productivity change (tfpch+) copied the development of production and subsidies with general increase during the evaluated period. The peak of FNVA of conventional farming was found in 2014 as mentioned in previous parts. Organic farms with negative development varied with the lack of farming strategy. FNVA of organic farms calculated per hectare was slightly lower than the conventional one, but it was significantly higher when calculated per annual work unit (about 11% in average). Nieberg and Offermann (2008) compared FADN data from Germany and found average Income per annual work unit of organic farms about 21% higher than the profit of conventional farms. Their analysis showed that 11 % of analysed organic farms achieved only half as high a FNVA as their conventional counterparts. On the other hand, about 14% of the analysed organic farms could realize double of FNVA of their conventional comparison partners. Substitution of labour work by capital or contract work could positively affect income indicator FNVA per AWU in farms of mixed crop and livestock production (Špička, 2014).

Comparison of significance

Efficiency of farming results from input and output parameters. The importance of basic characteristics on the panel data sample was tested by statistical comparison. Results are summarized in Table 6. Utilized Agricultural Area, Total of Livestock Units, Total Intermediate Consumption per Livestock Unit, Total of Current Subsidies, and Farm Net Value Added per AWU were proved as highly statistically significant parameters ($\alpha = 0.01$). Statistically significant characteristics ($\alpha = 0.05$) Livestock Output per hectare, Total Output per AWU, Depreciation per hectare, and Farm Net Value Added per hectare were identified.

Importance of inputs and outputs related to farm efficiency of different types of production was evaluated several times. Organic as well as conventional farms analysed in our research with positive development used larger areas than farms with negative change of efficiency. Successful farms have larger arable areas with more diversified crop production and cultivate more cash-crops such as potatoes and vegetables (Balcombe et al., 2005; Nieberg and Offermann, 2008; Špička, 2014; Madau, 2015). In contrast, Boudný et al. (2011) found larger total Utilized Agricultural Area in farms with negative development of technical efficiency. Farms had larger areas of permanent grassland, lower intensity of dairy cows and poultry but higher intensity of cattle and sheep. Technical efficiency is negatively influenced by the number of plots and location in less-favoured areas (Madau, 2015).

Polish farms with an increase in productivity are more capital intensive, run by younger and most educated farmers, and more integrated in factor and product markets than farms with decreasing productivity (Balcombe et al., 2005). Positively developing farms use more hired labour and are less dependent on the family members work. Hired labour might be more qualified and more able to perform specialised tasks than family labour, as well (Balcombe et al., 2005; Latruffe et al., 2008). Conventional farms in our evaluation showed higher Labour Input per 100 ha than organic ones. Differences between positive and negative groups were very small. Contrary to our results, Špička and Machek (2015) found significantly lower Labour Input per hectare in group of successful dairy farms connected to the lower livestock intensity.

Most authors describe significant impact of Utilized Land Unit (Balcombe et al., 2005; Nieberg and Offermann, 2008; Špička, 2014; Čechura et al., 2015; Madau, 2015; Špička and Machek, 2015), Labour Input (Balcombe et al., 2005; Latruffe et al., 2008; Čechura et al., 2015; Špička

Indicator	Unit	"Group A (μ_1) tfpch < 1 N = 845"	"Group B (μ_2) tfpch >= 1 N = 1355"	H0 (μ_1 - μ_2)	T-Statistic	P-value	Sig.
Utilized agricultural area	ha/farm	648.7922	824.8142	$\mu_1 - \mu_2 > 0$	-4.66167	0.000003	++
	S_x	801.6664	896.6447				
Total livestock units	LU	61.39293	57.12306	$\mu_1 - \mu_2 > 0$	3.077915	0.00211	++
	Sx	27.58457	33.93544				
Labour input	AWU/100ha	3.613292	3.477567	$\mu_1 - \mu_2 > 0$	1.28368	0.199389	-
	S_x	2.053843	2.610631				
Total output	CZK/ha	32597.45	33242.88	$\mu_1 - \mu_2 > 0$	-0.774615	0.438651	-
	S_x	17858.79	19691.11				
Crop output	CZK/ha	13261.19	13515.47	$\mu_1 - \mu_2 > 0$	-0.681497	0.495629	-
	S_x	7669.473	8997.824				
Livestock output	CZK/ha	27940.45	29440.91	$\mu_1 - \mu_2 > 0$	-2.17631	0.029638	+
	S_x	14859.45	16246.75				
Total output per AWU	CZK/AWU	1013128	1065417	$\mu_1 - \mu_2 > 0$	-2.13175	0.033138	+
	S_x	548223.2	566532.0				
Total intermediate consumption per hectare	CZK/ha	24637.28	25001.95	$\mu_1 - \mu_2 > 0$	-0.700778	0.483516	-
	S_x	11448.03	12127.62				
Total intermediate consumption per livestock unit	CZK/LU	43466.57	48113.87	$\mu_1 - \mu_2 > 0$	-4.54182	0.000006	++
	S_x	20213.71	25096.99				
Depreciation per hectare	CZK/ha	4297.717	4494.118	$\mu_1 - \mu_2 > 0$	-1.50932	0.131362	+
	S_x	2787.781	3075.938				
Investment subsidies	CZK/ha	661.6242	736.6857	$\mu_1 - \mu_2 > 0$	-0.522505	0.601371	-
	S_x	3302.229	3261.627				
Total current subsidies	CZK/ha	10967.25	11475.76	$\mu_1 - \mu_2 > 0$	-2.96727	0.003037	++
	S_x	3694.466	4037.858				
Farm net value added (FNVA) per hectare	CZK/ha	14374.90		$\mu_1 - \mu_2 > 0$	-1.71478	0.086527	+
	S_x	8189.381	8609.347				
Farm net value added (FNVA) per AWU	CZK/AWU	475245.9	515949.3	$\mu_1 - \mu_2 > 0$	-3.26059	0.001129	++
	S_x	288020.2	282753.8				

Note:
Sx = Standard Deviation,
Significance level: - no significance, + statistically significant (α = 0.05), ++ statistically highly significant (α = 0.01)
Source: authors, based on Farm Accountancy Data Network (FADN CZ) (2016)

Table 6: Structural and production differences between groups with increasing and decreasing technical efficiency in the period 2011-2015.

and Machek, 2015), Total Livestock Unit (Špička and Machek, 2015), Crop and Livestock Production (Boudný et al., 2011; Špička, 2014; Čechura et al., 2015; Špička and Machek, 2015), Total Costs - Specific and Other Material (Boudný et al., 2011; Čechura et al., 2015; Špička and Machek, 2015), and higher income per AWU and per hectare (Špička, 2014). Total current subsidies per hectare or Farm Net Value Added per hectare did not significantly differ (Boudný et al., 2011; Špička, 2014).

Conclusion

This paper focused on the structural and production differences between groups with the positive and negative change of technical efficiency in the period 2011 – 2015. To analyse the changes, DEA Malmquist indices of total factor productivity were used. The sample of panel data of 440 farms represented enterprises with livestock production divided into 114 organic and 326 conventional ones. Based on the total factor productivity change index, the statistical description and hypothesis testing, the results revealed some important findings related to FADN organic and conventional farms.

1. The results showed very small difference in technical efficiency between compared groups of farms and the relatively insignificant changes in time. Estimated TFP did not indicate fundamentally significant

growth or significant differentiation between holdings. The analysis of technical efficiency of livestock type of farming reveals 169 farms with negative and 271 farms with positive change in the productivity efficiency. In the period 2011 - 2015, about 69% of organic enterprises (79 from 114 farms) showed the productivity growth (i.e. the change in Total factor productivity of 3.17%), mainly due to technical (technological) efficiencies with growth of 2%. A total of 59% of conventional enterprises (192 from sample of 326 farms) were managed with increasing productivity with change TFP by 1.48%.

2. The group of farms with positive change in the production efficiency had significantly higher average agricultural utilised area, livestock units (LU) per farms and total consumption related to LU than group of farms with negative change. In terms of production there are statistically significant difference in production per total labour input (AWU) and for the livestock production. Statistically significant difference in depreciation indicates higher investment activities of farms with growing TFP. Subsidies on rural development and LFA subsidies significantly determines the FNVA. The analysis proved highly significant difference in FNVA per AWU between both groups of farms.

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