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Profitability development of Czech dairy farms

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Abstract: The paper deals with the development and main determinants of the profitability of Czech dairy farms. The aim of the paper is to evaluate the differences in the dynamics of profitability for two types of milk producers – specialized dairy farms and mixed farms – within the context of the agricultural policy changes. This aim is achieved by decomposing profitability into output growth, output and input price changes, changes in decoupled subsidies, technical change, scale, mark-up, and technical efficiency change components based on input distance function estimation. Based on the panel data obtained from the FADN database in the time period 2004–2011, it was found that the change in profitability was positive in the analysed time period, and slightly higher for the specialized dairy farms than for the mixed ones. The changes in output price, mark-up component and technical change are the main determinants of the development of profitability. Agricultural policy measures had different effects on these components. The strongest correlation was between the operational subsidies and the technical change and technical efficiency change, and this correlation was negative.

Keywords: Czech Republic, dairy, decomposition, input distance function, policy, profitability

Since the 1990s, the Czech dairy sector has been subjected to a couple of important institutional and structural changes. These changes were predetermined by the transition of the Czech economy and the accession of the Czech Republic to the European Union, the events which significantly influenced the performance, structure and size of the dairy sector. The developments in the dairy sector after 2004 can be characterized by a reduction in the numbers of cows, the growth in milk yield, capital market imperfections, a high dependency of local farm price on the world market price developments, an increase in the share of milk produced on specialized dairy farms, and the strong dependency of the farm performance on policy measures, namely quotas and subsidies.

The current position of the dairy sector can be described in terms of the basic production and trade characteristics. Milk production fluctuates around 2700 mil. l (the average in 2004–2013 was 2695 mil. l), with average yields of 6936 kg per cow and 560 945 cows on average. Frelich et al. (2011) added that about 60% of dairy cows have been reared in mountainous areas. Slightly more than half (58%) of Czech milk production is produced on specialized dairy farms. The rest of the milk production comes from the mixed crop and livestock farms. This share of the specialized dairy farms is very low compared to the old EU member states, where the share is 95% on average. This situation has affected the competitiveness of the Czech dairy sector, because the specialized farms are supposed to be more technically efficient than the mixed farms. Most of the milk volume produced in the Czech Republic is marketed through the milk producers' organizations (MPOs). Bošková (2014) quantified that the share of the MPOs in the raw milk sales is 70%.

The typical Czech milk-specialized farm has 138 cows, with the milk yield of 6814 kg per cow, producing 942 t of milk per year. Compared to the rest of the EU member states, Czech specialized farms have slightly lower milk yields (1.4% lower than the EU average); however, they have a higher production (due to having almost five times as many cows), which results in the by 4% lower price (the average price is 7.83 CZK/l, 0.32 EUR/l). The gross margin with coupled payments of the average Czech specialized dairy farm is one of the lowest among the EU member states. The coupled payments included in the gross margin are the Complementary National Direct Payments and Ruminants (the average value in the period 2005–2011:

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1784 CZK/cow, 73 EUR/cow) and the subsidies based on Article No. 68, Council regulation 73/2009 (average value for 2010–2012: 2071 CZK/cow, 84 EUR per cow). Besides these subsidies, dairy farms are also supported by the Single Area Payment Scheme and gain advantages in the investment support. Doucha et al. (2012) added that the profitability of milk production would be negative without these subsidies. On the other hand, under the suppositions, the total profitability of milk production can be relatively high (about 10%). Milk producers also faced a milk quota, which was abolished in April 2015.

An objective of the research is to evaluate the development and main determinants of the profitability of Czech dairy farms. More specifically, the presented research examines the dynamics of productivity and profitability within the context of the agricultural policy changes. The paper addresses the following research questions: Are the specialized dairy farms more technically efficient than the mixed farms? How did the profitability develop in the specialized and mixed farms? And what were its main determinants? Were the profitability components of dairy farms positively influenced by the subsidies and milk quotas?

The achievement of the research objectives has extended the knowledge of the Czech dairy sector economics and the competitiveness of dairy farms. The performance of Czech dairy farms has been analysed in only a few studies (see Foltýn et al. 2009; Frelich et al. 2011; Perný and Kubíčková 2011; Doucha et al. 2012; Čechura et al. 2014; Špička and Smutka 2014) and these studies usually measured the performance physically by the total factor productivity and technical efficiency. Kumbhakar and Lien (2009) pointed out that the maximization of productivity growth might not correspond with the profit maximization that is the goal of most producers. They suggested measuring the performance in terms of profit, and they decomposed profitability into components such as output growth, output and input price changes, technical change, returns to scale, mark-ups, and technical efficiency change.

The rest of the paper is organized as follows. We begin by introducing the data and the methods used. We then present the results of our analysis. Firstly, the IDF estimates are commented on and the technical efficiency of milk producers is discussed. Secondly, we analyse the development of profitability and its components. Finally, the impact of agricultural policy on the profitability change is analysed.

MATERIALS AND METHODS

The performance of Czech dairy farms is based on the extension of the Sipiläinen et al. (2013) approach to the profitability decomposition, see equation (1).

$$\frac{1}{C}\frac{d\pi}{dt} = \dot{Y}_P\left(\frac{R}{C}-1\right) + \dot{P}\frac{R}{C} + \frac{1}{C}\dot{DS} - \dot{W} + TC + \\ + \left[(1-RTS^{-1})\dot{Y}_C\right] + \left(\dot{Y}_P - \dot{Y}_C\right) + \dot{TE} \qquad (1)$$

where π is profit, R is the total revenue, C is total cost, $\dot{Y}_P$ is the rate of the change in output weighted by the output revenue shares, $\dot{Y}_C$ is the rate of the change in output weighted by estimated output cost elasticities, $\dot{P}$ is the rate of the change in output price, $\dot{DS}$ is the rate of the change in decoupled subsidies, $\dot{W}$ is the input price change, TC is technical change, RTS is returns-to-scale, $\dot{TE}$ is technical efficiency change, and t is time.

Equation (1) was derived on the basis of several assumptions. The existence of a milk quota restricts the maximum milk output of producers. The local price is greatly influenced by the world market price. The goal of profit maximization can be achieved by minimizing the cost of producing a fixed (quota) output. Profit is directly influenced by decoupled subsidies (Henningsen et al. 2011).

From Equation (1), it is evident that the profitability change can be decomposed into eight components: (i) the output growth component $\dot{Y}_P(R/C-1)$, (ii) the output price change component $\dot{P}(R/C)$, (iii) the decoupled subsidies change component $\frac{1}{C}\dot{DS}$, (iv)the input price change component $\dot{W}$, (v) the technical change component TC, (vi) the scale component $(1-RTS^{-1})\dot{Y}_C$, (vii) the mark-up component $\dot{Y}_P - \dot{Y}_C$ and (viii) the technical efficiency change $\dot{TE}$. Kumbhakar and Lien (2009) noted that the scale component is zero if the RTS is unity (optimum scale) and that the mark-up component is zero if the output prices are competitive and the marginal cost pricing rule is followed. If the technical change component is positive, profitability will increase over time, ceteris paribus. The increase in profitability is also caused by the positive technical efficiency change, the output price increase and the input price decrease.

The components (i)–(iv) can be computed directly from the observed data:

$$\dot{Y}_P\left(\frac{R}{C}-1\right) = \sum_m R_m \frac{\left(Y_{m,t}-Y_{m,t-1}\right)}{0.5\left(Y_{m,t}+Y_{m,t-1}\right)}\left(\frac{R}{C}-1\right) \qquad (2)$$

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where: $R_m = \frac{P_m Y_m}{\sum_m P_m Y_m}, \frac{R}{C} = \frac{\sum_m P_m Y_m}{\sum_j W_j X_j}$ (3)

where: P_m is the price of output m (m = 1, ..., M), Y_m is a quantity of output m (m = 1, ..., M), W_j is the price of output j (j = 1, ..., J) and X_j is a quantity of input j (j =1, ..., J).

$$\dot{P}\frac{R}{C} = \sum_m R_m \frac{(P_{m,t} - P_{m,t-1})}{0.5(P_{m,t} + P_{m,t-1})}\frac{R}{C} \tag{4}$$

$$\dot{DS}\frac{1}{C} = DS\frac{(DS_{m,t} - DS_{m,t-1})}{0.5(DS_{m,t} + DS_{m,t-1})}\frac{1}{C} \tag{5}$$

$$\dot{W} = \sum_j \frac{W_j X_j}{\sum_j W_j X_j}\frac{(W_{j,t} - W_{j,t-1})}{0.5(W_{j,t} + W_{j,t-1})} \tag{6}$$

We calculated these rates of change between two evaluated points (t and t – 1) by using the average return and cost shares at these two points as weights. This is similar to the Tornquist index – see the example for the return share of milk in (7).

$$R_1 = \frac{0.5(P_{1,t} + P_{1,t-1})0.5(Y_{1,t} + Y_{1,t-1})}{0.5(R_t + R_{t-1})} \tag{7}$$

The rest of the revenue shares were calculated based on Equation (8) due to the lack of other output (plant and other animal outputs) prices:

$$R_m = \frac{0.5(MO_{m,t} + MO_{m,t-1})}{0.5(R_t + R_{t-1})} \tag{8}$$

where: MO_{m-1} is the monetary value of output m (m = 2, ..., M).

As noted by Sipiläinen et al. (2013), the use of averages for the consecutive periods t – 1 and t ensures that the analysis is time-consistent for 'static' variables.

The computation of the remaining components (v)–(viii) is based on the estimation of the cost function.

The estimation of the cost function requires information about input prices. However, as this information is limited and the variability of input price is low for such estimation, we employ the duality theorem and estimate the input distance function (IDF, Coelli et al. 2003). Using the homogeneity property, we can estimate the following stochastic translog IDF with M outputs and J inputs based on panel data (Equation (9)).

$$-\ln X_{1i,t} = (\alpha_0) + \sum_{m=1}^{M}\beta_m \ln Y_{mi,t} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{N}\beta_{mn}\ln Y_{mi,t}\ln Y_{ni,t} + \sum_{m=1}^{M}\sum_{j=2}^{J}\delta_{mj}\ln Y_{mi,t}\ln \tilde{X}_{ji,t} + \sum_{j=2}^{J}\beta_j \ln \tilde{X}_{ji,t} + \frac{1}{2}\sum_{j=2}^{J}\sum_{k=2}^{K}\beta_{jk}\ln \tilde{X}_{ji,t}\ln \tilde{X}_{ki,t} + \alpha_t t + \frac{1}{2}\alpha_{tt}t^2 + \sum_{m=1}^{M}\alpha_{mt}\ln Y_{mi,t}t + \sum_{j=2}^{J}\beta_{jt}\ln \tilde{X}_{ji,t}t + v_{i,t} - u_{i,t} \tag{9}$$

where: , $\ln \tilde{X}_{ji,t} = \ln X_{ji,t}$, α, β, δ are parameters to be estimated. The symmetry restrictions imply that $\beta_{jk} = \beta_{kj}$ and $\beta_{mn} = \beta_{nm}$. $v_{i,t} \sim iidN(0,\sigma_v^2)$ is a stochastic error term and $u_{i,t} \sim N^+(\mu, \sigma_{ui,t}^2)$ is the time-varying inefficiency.

We also normalised all variables in logarithm by their sample mean, which makes it possible to interpret the estimated first-order parameters as elasticities at the sample mean.

In order to capture the farm heterogeneity, equation (9) was estimated in the form of a Random Parameter Model using the maximum simulated likelihood method in the econometric software LIMDEP 9.0.

Following Kumbhakar and Lien (2009), the TC component, which takes into account the averages of the consecutive periods t – 1 and t, can be computed from IDF as in Equation (10):

$$TC = -\frac{\partial \ln X_1}{\partial t} = \alpha_t + \alpha_{tt}t + \sum_{m=1}^{M}\alpha_{mt}\ln Y_{mi,t} + \sum_{j=2}^{J}\beta_{jt}\ln \tilde{X}_{ji,t} \tag{10}$$

The scale component is computed using the following Equations (11)–(13):

$$RTS = \frac{1}{\sum_m \partial \ln X_1 / \partial \ln Y_m} \tag{11}$$

$$\frac{\partial \ln X_1}{\partial \ln Y_{mi,t}} = -\left(\beta_m + \sum_{n=1}^{N}\beta_{mn}\ln Y_{ni,t} + \sum_{j=2}^{J}\delta_{mj}\ln \tilde{X}_{ji,t} + \alpha_{mt}t\right) \tag{12}$$

$$\dot{Y}_C = RTS\sum_m \frac{\partial \ln X_1}{\partial \ln Y_{mi,t}}\frac{(Y_{m,t} - Y_{m,t-1})}{0.5(Y_{m.t} + Y_{m,t-1})} \tag{13}$$

Equation (13) is also used to compute the mark-up component. Finally, the technical efficiency change is computed using Equation (14):

$$\dot{TE}_{i,t} = \frac{TE_{i,t} - TE_{i,t-1}}{0.5(TE_{i,t} + TE_{i,t-1})} \tag{14}$$

where the technical efficiency is estimated using the Jondrow et al. (1982) approach.

Moreover, we analysed the impact of subsidies and milk quotas on the selected profitability components, namely: the milk growth component, the total output growth component, the milk price change component,

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the total output price change component, the land price change component, the technical change component, scale component, the mark-up component and the technical change component. The impact was analysed with the Spearman's rank correlation coefficients, computed with the rates of change of subsidies and milk quotas (computed similarly to the change in the technical efficiency, see Equation 14). Following the findings of Minviel and Latruffe (2014) that each type of subsidy has to be treated separately in the empirical analysis, we divided the total farm subsidies into two main groups: investment subsidies and operational subsidies (total subsidies excluding investments). In addition, we separately analysed the Agri-Environment (AEO) and the Less Favoured Areas (LFA) payments.

The analysis uses an unbalanced panel data set drawn from the FADN database. The data covers the period from 2004 to 2011. Information on two types of production are used: the specialized milk production, covering farms whose share of milk production in the total production is higher than 40% (1577 cases), and the mixed production (2642 cases). For the estimation of the IFD in this study, we used the following outputs and inputs: milk production in litres (y_1), other animal production (y_2), plant production (y_3), labour measured in AWU (x_1), the total utilized land in hectares (x_2), the cost of feed for grazing livestock (x_3), the costs of other materials (x_4), and capital measured as the sum of contract work and depreciation (x_5).

Table 1 presents the basic statistical characteristics of the above-mentioned variables as well as subsidies.

Table 1. Characteristics of sample

	Mean	Std. Deviation	Minimum	Maximum	Cases
SPECIALIZED DAIRY FARMS					
AWU	25	30	1	178	1 577
Land (ha)	671	729	1	5 118	1 577
Feed (€)	185 837	223 901	2 218	1.32E+06	1 577
Other materials (€)	158 841	225 817	245	1.42E+06	1 577
Capital (€)	121 201	145 981	114	1.11E+06	1 577
Milk production (l)	1.43E+06	1.72E+06	16 100	1.16E+07	1 577
Other animal production (€)	111 957	157 479	115	1.41E+06	1 577
Plant production (€)	238 191	324 289	807	2.21E+06	1 577
Milk subsidies (€)	5 301	13 832.3	0	89 191	1 577
Total subsidies – excluding investments (€)	205 450	227 858	0	1.21E+06	1 577
Agri-environment subsidies (€)	206 688	225 764	0	1110493	1 577
LFA subsidies (€)	24 412	38 288	0	340 420	1 577
Investment subsidies (€)	10 019	47 207	0	608 683	1 577
Decoupled subsidies (€)	77 544	94 991	0	694 418	1 577
MIXED FARMS					
AWU	48	43	1	308	2 642
Land (ha)	1 348	1 059	6	7 310	2 642
Feed (€)	247 200	220 306	532	1.49E+06	2 642
Other materials (€)	459 186	475 755	367	3.36E+06	2 642
Capital (€)	231 749	224 847	132	1.84E+06	2 642
Milk production (l)	1.65E+06	1.57E+06	400	1.20E+07	2 642
Other animal production (€)	287 112	364 045	4	4.03E+06	2 642
Plant production (€)	718 676	728 817	933	7.28E+06	2 642
Milk subsidies (€)	4 170	11 856	0	97 810	2 642
Total subsidies – excluding investments (€)	348 253	294 693	0	2.32E+06	2 642
Agri-environment subsidies (€)	29 423	39 900	0	448 408	2 642
LFA subsidies (€)	21 127	33 833	0	412 246	2 642
Investment subsidies (€)	21 029	90 308	0	1.41E+06	2 642
Decoupled subsidies (€)	152 705	137 437	0	957 861	2 642

Source: own calculations

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These characteristics are presented separately for the specialized dairy farms and for the mixed farms. The specialized dairy farms are smaller than the mixed farms in the terms of the number of workers as well as the agricultural land utilized. This, connected with the lower volume of other inputs, leads to a lower production, per farm, of all products. On the other hand, the specialized dairy farms achieved higher milk yields (6313 l/cow) compared to mixed farms (5853 l/cow in average). In addition, the actual price of milk production is slightly higher for the specialized dairy farms (0.29 EUR/l compared to 0.28 EUR/l for the mixed farms). That is, the specialized dairy farms can produce higher quality milk than the mixed farms.

Both types of farms can be characterized by a large share of the rented agricultural land. This share is slightly higher for the mixed farms (87% in average), compared to 77% for the specialized dairy farms. The higher share of paid labour inputs (79% in average) is also typical of the mixed farms. However, the higher share of family workers is more common in the specialized dairy farms (40%). The specialized dairy farms are also more capital-consuming. The average capital per hectare share is 181 EUR for this type of milk producers, whereas it is 172 EUR for the mixed farms.

The specialized dairy farms are also more likely than the mixed ones to be located in the less favoured areas.

Table 2. Parameters estimate

Means for random parameters				Scale parameters			
Variable	Coeff.	SE	P [|z| > Z*]	Variable	Coeff.	SE	P [|z|>Z*]
Const.	0.0845***	0.0037	0.0000	Const.	0.5129***	0.0035	0.0000
Time	0.0155***	0.0006	0.0000	Time	0.0060***	0.0014	0.0000
Y1	–0.2830***	0.0028	0.0000	Y1	0.0746***	0.0048	0.0000
Y2	–0.0569***	0.0022	0.0000	Y2	0.0107***	0.0031	0.0005
Y3	–0.3012***	0.0028	0.0000	Y3	0.0874***	0.0047	0.0000
X2	0.5187***	0.0049	0.0000	X2	0.0342***	0.0065	0.0000
X3	0.1755***	0.0040	0.0000	X3	0.0293***	0.0071	0.0000
X4	0.0874***	0.0041	0.0000	X4	0.0368***	0.0055	0.0000
X5	0.0287***	0.0028	0.0000	X5	0.0458***	0.0049	0.0000
Non-random parameters							
TT	0.0056***	0.0006	0.0000	X23	–0.1089***	0.0091	0.0000
Y1T	–0.0026***	0.0009	0.0071	X24	0.0017	0.0067	0.7942
Y2T	0.0030***	0.0007	0.0000	X25	0.0017	0.0052	0.7418
Y3T	0.0011	0.0011	0.3228	X34	–0.0138**	0.0065	0.0344
Y11	–0.0830***	0.0022	0.0000	X35	–0.0010	0.0045	0.8173
Y22	–0.0273***	0.0023	0.0000	X45	–0.0061	0.0041	0.1364
Y33	–0.0795***	0.0043	0.0000	Y1X2	0.0381***	0.0052	0.0000
Y12	0.0058***	0.0020	0.0033	Y1X3	–0.0094**	0.0040	0.0170
Y13	0.0071**	0.0032	0.0282	Y1X4	0.0113***	0.0034	0.0010
Y23	0.0196***	0.0025	0.0000	Y1X5	0.0067**	0.0027	0.0115
X2T	–0.0026	0.0021	0.2148	Y2X2	0.0108**	0.0045	0.0173
X3T	0.0077***	0.0016	0.0000	Y2X3	–0.0041	0.0032	0.2032
X4T	–0.0051***	0.0014	0.0002	Y2X4	–0.0097***	0.0034	0.0037
X5T	–0.0003	0.0010	0.7813	Y2X5	–0.0043*	0.0024	0.0698
X22	0.2087***	0.0101	0.0000	Y3X2	–0.0004	0.0059	0.9459
X33	0.1204***	0.0083	0.0000	Y3X3	–0.0111**	0.0048	0.0222
X44	0.0390***	0.0068	0.0000	Y3X4	0.0151***	0.0048	0.0017
X55	0.0092**	0.0038	0.0157	Y3X5	0.0214***	0.0037	0.0000
Sigma	0.1022***	0.0018	0.0000				
Lambda	1.3733***	0.0889	0.0000				

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

Source: own calculations

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In 80% of cases, the specialized dairy farms gained an LFA subsidy, whereas this subsidy was drawn in only 61% of cases with the mixed production.

Outputs as well as inputs (except for the milk production, labour and land) are deflated by price indices (individual output and input indices (2005 = 100) – source the EUROSTAT database).

The output price for milk and input prices for labour and land are obtained from the FADN database. Price indices obtained from the EUROSTAT database are substituted for the rest of the prices.

RESULTS AND DISCUSSION

Table 2 provides the estimated parameters of the IDF model. Almost all parameters are significant even at the 1% significance level. As far as the theoretical consistency is concerned, the estimated model implies that the estimation should inherit the properties of an input distance function. According to Lovell et al. (1994), the input distance function must fulfil the following conditions: symmetry, monotonicity and positive linear homogeneity, non-decreasing and convex in outputs, and decreasing in inputs. These requirements imply: $\beta_{xj} > 0$ and $\beta_{ym} < 0$ for $j = 2, \ldots, 5$ and $m = 1, \ldots, 3$. Table 2 shows that these conditions are met.

Since all variables are normalised in logarithm by their sample mean, the first-order parameters can be interpreted as the elasticity of the IDF with respect to output and as the shadow value share with respect to inputs on the sample mean. As can be seen from Table 2, the input share of capital is the lowest (0.0287), the input share of land is the highest (0.5187), and the elasticity of the milk yield is about 0.2830 and it is slightly lower than the elasticity of the plant outputs (0.3012). That is, the share of capital in the total cost is only 3%; however, the share of land is about 51%. This reflects the high share of the rented land and also the absence of innovations in milk production connected with the capital market imperfections, especially at the beginning of the analysed time period. This result was also confirmed by Čechura et al. (2014).

The parameter lambda is highly significant and greater than one. The variation in u_{it} is more pronounced than the variation in the random component v_{it}. This indicates that most of the deviation from the border of the input requirement set is due to technical inefficiencies rather than random shocks.

The average technical efficiency of the specialized dairy farms is 93.77%, with the standard deviation at the level of 2.87%. Mixed farms are almost as technically efficient as the specialized dairy farms (the average technical efficiency of mixed farms is 93.83%, with the standard deviation equal to 2.68%). That is, the distribution of technical efficiency is narrow for both types of milk-producing farms. In addition, the extreme values are similar. The minimum value is 69.56% for the specialized dairy farms and 67.90% for the mixed farms. Specialized dairy farms achieved 98.74% as the maximum value of technical efficiency, and mixed farms reached 98.47%. These results are

Table 3. Calculated profitability change components (in percent)

Components	SPECIALIZED DAIRY FARMS				MIXED FARMS			
	mean	std. dev.	min.	max.	mean	std. dev.	min.	max.
Output growth	–0.015	0.074	–0.414	0.293	–0.001	0.070	–0.359	0.507
Milk	–0.003	0.051	–0.495	0.224	0.001	0.026	–0.283	0.120
Plant production	–0.008	0.047	–0.308	0.163	–0.003	0.055	–0.209	0.360
Other animal production	–0.004	0.034	–0.204	0.152	0.001	0.036	–0.164	0.303
Output price change	0.013	0.071	–0.221	0.561	0.011	0.072	–0.195	0.167
Milk price change	0.008	0.042	–0.141	0.522	0.007	0.023	–0.073	0.081
Decoupled subsidies change	0.008	0.007	–0.054	0.083	0.008	0.005	–0.012	0.074
Input price change	0.054	0.502	–1.573	1.665	0.045	0.428	–1.372	1.446
Technical change	0.016	0.011	–0.014	0.041	0.013	0.012	–0.015	0.043
Scale	–0.135	0.750	–5.935	3.269	–0.043	0.297	–4.219	2.074
Mark-up	0.376	1.872	–7.241	14.463	0.154	0.909	–5.446	9.966
Technical efficiency change	–0.001	0.044	–0.324	0.221	–0.003	0.036	–0.191	0.242
Profitability change	0.116	1.055	–4.826	8.674	0.084	0.783	–3.326	6.942

Source: own calculations

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compatible with the results of Čechura et al. (2014), which used the Fixed Management Model (FMM) to analyse the technical efficiency of Czech and Slovak farms which produce milk.

Table 3 presents the components of profitability for both types of farms. For the specialized as well as mixed farms, the output growth component was, in average, negative. This low average output decrease can be explained by the milk quota regulation, which was difficult to fulfil in the first years of its implementation. Figures 1 and 2 show that the primary output decrease was more pronounced for the specialized farms than for the mixed farms. For the specialized dairy farms, the negative impact of the output component can be seen in almost every year under evaluation. A positive impact was observed only in 2011, when the Czech as well as the EU milk market recovered after the milk crises. On the other hand, the output contributed positively to profitability growth in 2006 and 2010 for the mixed farms. This positive effect was due to the contribution of plant production in the year 2006 and by other animal production in the year 2010. Diversification of production helps farms to better face the problems associated with one commodity market.

The output price change component was found to be positive for both types of farms and slightly higher for the specialized milk farms than for the mixed farms. The output price change negatively affected the profitability of both types of farms only in 2005 and 2009, when a significant decrease in the price of milk took place in the commodity market.

The decoupled subsidies component had a positive impact on the profitability of both types of farms, with its average contribution being almost the same. This holds true for all analysed years. The high dependency of Czech animal producers on subsidies was also confirmed by the results of Lososová and Zdeněk (2014).

The input price change component negatively affected profitability (see Equation (1)), and this effect was more pronounced for the specialized dairy farms (0.054% per annum). From the analysed inputs, capital had the highest average negative impact (0.039% per annum for the specialized dairy farms and 0.027% for the mixed farms). That is, input prices have different impacts on the mixed farms and on the specialized dairy farms. In average, work has a higher negative impact on the mixed farms than on the specialized dairy farms; however, the opposite holds true for feed. The same impact can be observed in the case of land. That is, the profitability of a specialized dairy farm is more dependent on the price of the purchased feed and the price of capital, because it is more capital-consuming. On the other hand, the higher share of family workers resulted in lower dependency on changes in work price for the specialized dairy farms than for the mixed farms. Input price negatively contributed to the profitability change, especially in the years 2006, 2007, 2008 and 2010 for the specialized dairy farms. For the mixed farms, a negative contribution can be observed in the years 2006–2009.

The technical change component contributed positively for both types of farms and was slightly more pronounced for the specialized dairy farms (0.016% per annum). That is, the specialized farms employed investments slightly more in order to shift

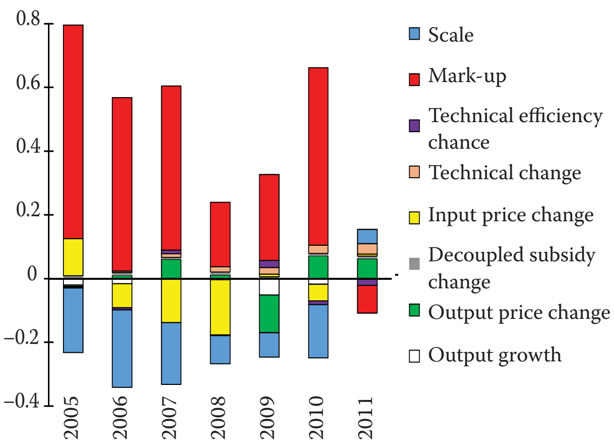

Figure 1. Profitability development – specialized farms

Source: own calculations

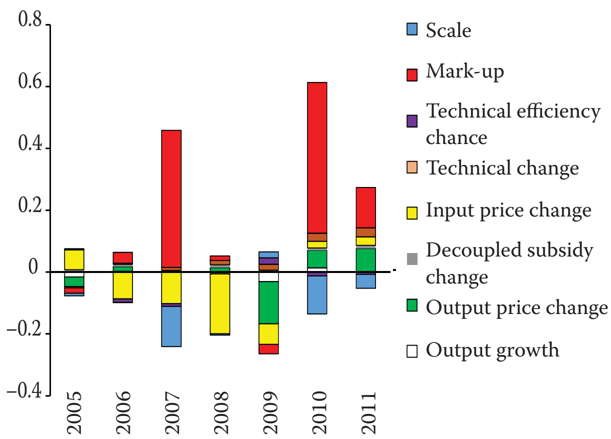

Figure 2. Profitability development – mixed farms

Source: own calculations

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their production frontier. One can suppose that the positive contribution of technical change was due to the modernization and innovations supported by the investment subsidies. However, this was not statistically confirmed – see Table 4 where the Spearman's rank correlation coefficients between the investment subsidies change and technical change are presented.

The scale component was also more pronounced in the specialized dairy farms than in the mixed farms. However, its contribution was negative, and the returns to scale were greater than one for both types of farms (1.44 for the specialized dairy farms and 1.38 for the mixed farms). This result implies that milk producers in the Czech Republic, especially the specialized dairy farms, did not operate on an effective scale. In other words, milk producers did not, on average, completely exploit the economies of scale. Similar results were obtained by Kumbhakar and Lien (2010) for dairy farms in Norway. The scale component contributed positively to the profitability of the specialized dairy farms only in 2011, and in 2009 in the case of the mixed farms.

The mark-up component contributed positively for both types of farms. However, it was more pronounced in the specialized dairy farms. A non-zero mark-up component implies that some market imperfections exist on the commodity market. This non-competitiveness is highly pronounced for almost the entire analysed time period (the year 2011 is the exception) in the case of the specialized dairy farms (Figure 1). This does not hold true for the mixed farms, where the mark-up component was rather low in 2005 and 2009. The specialization of agricultural production seems to be a factor which supports the market power of producers in the commodity market. In other words, the specialized dairy farms could take advantage of the monopolistic or oligopolistic rents.

Technical efficiency change contributed negatively to the profitability change for both types of farms. However, the average value of the technical efficiency component is close to zero, especially in the specialized dairy farms. Focusing on the development of this component, we can observe a positive contribution in the years 2007 and 2009 in the case of the specialized dairy farms, and in 2005 and 2009 for the mixed farms, when the farms caught up to the technical frontier (mean technical efficiency increased in these years).

Finally, the overall increase in profitability was higher in the specialized dairy farms (0.116% per annum) than in the mixed farms (0.084% per annum). However, the profitability change was less volatile in the mixed farms. A significant change in profitability was recognized in the year 2008 for both types of farms, but for the mixed farms the most significant negative probability change was in the year 2009, similarly to Doucha et al. (2012). This was due in particular to an output price decrease connected with crises in the EU commodity market (see the price output component in Figures 1 and 2). The following years can be characterized by an increase in profitability. This could also be the result of milk subsidies, which significantly increased due to the Article No. 68 and the national government regulation No. 87/2010.

The probability of milk producers is also influenced by the agricultural policy. The evaluation of

Table 4. Spearman´s rank correlation coefficients

	SPECIALIZED DAIRY FARMS					MIXED FARMS				
	operation	AEO	LFA	investment	quota	operation	AEO	LFA	investment	quota
Output growth	0.040	**0.112**	**0.080**	0.019	0.047	0.033	**0.063**	0.009	–0.017	**–0.078**
Milk growth	**0.072**	**0.062**	0.055	0.019	**0.073**	**0.079**	0.035	**0.048**	–0.021	**0.103**
Output price change	0.011	**0.206**	0.004	0.032	**–0.232**	**–0.191**	**0.062**	**–0.075**	0.003	**–0.378**
Milk price change	**0.138**	**0.141**	**0.110**	**0.061**	0.033	**–0.051**	–0.005	**0.099**	0.034	0.032
Land price change	0.026	**0.092**	0.038	–0.005	**0.131**	**0.069**	**0.049**	**0.060**	–0.001	**0.160**
Technical change	**–0.503**	**–0.174**	**–0.289**	–0.014	**–0.448**	**–0.553**	**–0.169**	**–0.210**	0.021	**–0.58**
Scale	**–0.065**	0.053	–0.029	–0.005	0.014	–0.002	0.039	0.009	0.007	**0.110**
Mark-up	**0.060**	–0.056	0.024	0.007	–0.030	–0.006	**–0.050**	–0.016	–0.006	**–0.130**
Technical efficiency change	**–0.166**	**–0.100**	**–0.184**	–0.007	**–0.197**	**–0.118**	**–0.087**	**–0.064**	–0.015	–0.015

Bold values denote significance at $p < 0.05$

Source: own calculations

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the impact of subsidies and quotas on the profitability component was based on the Spearman´s rank correlation coefficients, the computed values of which are presented in Table 4.

The total subsidies, excluding the change in investments (operational subsidies), are significantly positively correlated with the milk growth for both types of farms. However, the correlation between operational subsidies and output growth is very low. Because the decoupled payments account for the main part of this measure, we can conclude that the production effect of the decoupled payments is negligible, similar to Henningsen et al. (2009).

Focusing on the specific parts of operational subsidies, we can conclude that the increase in the agro-environment payments (as a part of the operational subsidies) was followed by an increase in all production for both types of farms. This shows that there can be a positive relationship between the production of market goods and public goods in the dairy sector. That is, a trade-off between agricultural production and public goods is not inevitable. This is in line with Barraquand and Martinet (2011) and Gullstrand et al. (2014), who analysed the relationship between milk and the provision of biodiversity. Moreover, a 'win-win' scenario is also possible, as mentioned by Power (2010). The increase in the LFA support was followed by an increase in milk production on the mixed farms; however, this relationship was not statistically significant for the specialized dairy farms.

A positive correlation can also be seen between the milk price and operational subsidies for the specialized dairy farms. Rizov et al. (2013) noted that a significant part of coupled subsidies (i.e. the LFA payments, the Complementary National Direct Payments and Ruminants, the subsidies based on the Article No. 68, Council Regulation 73/2009) could be leaked away to other agents through changes in market prices. A positive correlation also exists for the AEO payments. This is an important issue for the agricultural policy incidence and the evaluation of the agricultural policy efficiency, which should be a topic for a future research.

The statistically significant correlation coefficients between operational subsidies and the land price shows that the redeployment of subsidies from farmers to land owners was pronounced on the input market, especially in the case of the mixed farms.

Sipiläinen and Kumbhakar (2010) found that agricultural subsidies (specifically direct payments) negatively affected the technical change. The correlation coefficients presented in Table 4 also show a significant negative relationship between operational subsidies and technical change, and this holds true for both types of farms.

A negative correlation can also be observed between the changes in operational subsidies and the technical efficiency change. This was also confirmed by the results of Latruffe et al. (2008) and Rizov et al. (2013), which show that the public support received by Czech dairy farms reduced their technical efficiency and, furthermore, their overall competitiveness (Zhu et al., 2012). Technical efficiency is also negatively correlated between the AEO and LFA payments. More environmentally friendly farms seem to be less technically efficient, as confirmed by Kleinhanß et al. (2007) and Latruffe et al. (2011).

There is also a positive correlation between the mark-up component and operational subsidies in the specialized dairy farms. That is, this support can disturb the competitive condition on the commodity market

The supposed positive relationship between the investment subsidies and technical change, as well as between the investment subsidies and technical efficiency change (Minviel and Latruffe 2014), was not proved.

Finally, the abolishment of the milk quota was connected with an increase in milk production. We can suppose that the abolition of the milk quota in April 2015 will be followed by a further increase in the milk production, leading to a greater competitiveness in the commodity market connected with a decrease in the price of milk.

CONCLUSION

Milk production in the Czech Republic takes place on the specialized milk farms, as well as the mixed farms which also produce other animal outputs or plant products. These two types of farms differ in size as well as in the share of rented inputs (land and labour); however, the efficiency of the input use is almost the same for both types. The level of technical efficiency shows that the milk producers highly exploit their production possibilities. However, technical efficiency is not the most important determinant of profitability. Changes in price influenced the profitability change significantly more than did technical efficiency in the analysed time period. On average,

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profitability change was positive during this time and slightly higher for the specialized dairy farms than for the mixed farms. The output price change, technical change and mark-up components positively influenced the mentioned profitability change for both types of farms. On the other hand, the output growth, the input price change and technical efficiency change components had negative effects on the profitability growth.

These components were influenced by the agricultural policy changes. The implementation of a milk quota in the Czech Republic caused the output to decrease in the initial period, while its repeal led to a slight increase in the milk production. The recent abolition of the milk quota will probably be followed by a further increase in milk production, leading to a greater competitiveness in the commodity market connected with a decrease in the price of milk.

Agricultural subsidies also influenced profitability and its components, especially technical change, technical efficiency change and output (milk) price. Operational subsidies, as well as the AEO and LFA payments, reduced the motivation to innovate and produce efficiently, as a result of the farmers' decisions to trade off the market income for the subsidy income. On the other hand, these subsidies can contribute to the decision of farmers to produce public goods. Operational support also slightly affected the mark-up and input price change component, due to a disturbance in the competitive conditions in the commodity market as well as the partial shifts to input owners. These conclusions are important for the evaluation of the effectiveness of the Common Agricultural Policy, and open issues for the future research.

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