**Performance of Czech dairy farms in context of agricultural policy changes**

ZDENKA zakova KROUPOVA

*Department of Economics, Faculty of Economics and Management, Czech University of Life Sciences Prague, Prague, Czech Republic*

**Abstract:** The paper deals with the development of Czech dairy farms profitability and its main determinants. An aim of the paper is to evaluate the differences in the dynamics of profitability in two types of milk producers - specialized dairy farms and mixed farms and in the context of agricultural policy change. This aim is reached by decomposition of profitability into output growth, output and input price changes, technical change, returns to scale, mark-ups and technical efficiency change components based on input distance function estimation. Based on panel data gained from FADN database in time period 2004-2011, we found out that the profitability change was positive in analyzed time period and almost similar in both types of farms. The change in output price, the mark-up power and the technical change are the main determinants of this positive profitability development. The agriculture policy positively contributed especially to the influence of technical change.

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

**JEL Classification**: Q12, Q18

INTRODUCTION

Since 1990s, the Czech dairy sector has been subjected to a couple of important institutional and structural changes. These changes were predetermined by transition of the Czech economy and by the accession of the Czech Republic to the European Union, events which significantly influenced the performance, the structure and the size of dairy sector. The development in dairy sector after 2004 can be characterized by a reduction of cows, a growth of a milk yield, capital market imperfections, a high dependency of local farm price on world market price development, an increase of share of milk produced on specialized dairy farms and the strong dependency of farm performance on policy measurement, namely quotas and subsidies. The current position of the dairy sector can be described in terms of basic production and trade characteristics. The milk production fluctuates around 2,700 mil. l (the average in 2004–2013 was 2,695 mil. l) with the average yields in the value 6,936 kg per cow and 560,945 cows on average. Most of milk volume produced in the Czech Republic is marketed through milk producers’ organizations (MPOs). Bošková (2014) quantified the share of MPOs on raw milk sales on the level of 70 %. The production is realized on the market with 7.83 CZK/l average price (0.32 EUR/l).

Slightly more than half (58 %) of the Czech milk production is produced in specialized dairy farms. The rest of the milk production comes from mixed crop and livestock farms. This share of special dairy farms is very low compared to the situation in the old EU member states, where this share is 95 % on average. This situation affected competitiveness of Czech dairy sector, because specialized farms are supposed to be more technically efficient than mixed farms. They are highly technologically demanding.

A typical milk specialized Czech farm has 138 cows, with a milk yield of 6,814 kg per cow, producing 942 t of milk per year. Compared to the rest of EU member states, Czech specialized farms have slightly lower milk yield (1.4 % lower on average), however, they have higher production (due to almost five times higher number of cows), which realized with 4% lower price. Finally, the gross margin with coupled payments is one of the lowest in the EU member states. The coupled payments included in the gross margin are the Complementary National Direct Payments and Ruminants (an average value in period 2005-2011: 1,784 CZK/cow, 73 EUR/cow) and the subsidies based on Article No. 68, Council regulation 73/2009 (average value 2010-2012: 2,071 CZK/cow, 84 EUR/cow). Besides these subsidies, dairy farms are also supported by the Single Area Payment Scheme and gain advantages in investment support. Doucha et al. (2012) added that the profitability of milk production is negative without these subsidies. On the other hand, under the suppositions, the total profitability of milk production could be relatively high (about 10 %). The milk producers faced also to the milk quota, which was abolished in April 2015.

An objective of the research is to evaluate the development of Czech dairy farms profitability and its main determinants. More specifically, the presented research examines the dynamics of productivity and profitability in the context of agricultural policy change. The paper addresses the following research questions: Are specialized dairy farms more technically efficient then mixed farms? What was the profitability development in specialized and mixed farms? And which were its main determinants? Was the specialized dairy farms profitability positively influenced by subsidies as major instrument of Common Agriculture Policy?

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

A rest of the paper is organized as follows. First, we introduce the data and the methods we used. We then present the results of our analysis. Firstly, the IDF estimates are commented 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 profitability change is analysed.

MATERIALS AND METHODS

The performance of Czech dairy farms is based on Sipiläinen at al. (2013) extension of Kumbhakar and Lien (2009) approach to profitability decomposition, see equation (1).

 (1)

where *π* is profit, *R* is the total revenue, *C* is the total cost, is the rate of change in output weighted by output revenue shares, is the rate of change in output weighted by estimated output cost elasticities, is the rate of change in output price, is the input price change, *TC* is a technical change, *RTS* is returns-to-scale, is a technical efficiency change and *t* is time.

The equation 1 was derived on the base of several assumptions. The existence of milk quota restricts a producer maximum milk output. The local price is highly influenced with the world market price. The goal of profit maximizing can be achieved by minimizing the cost of producing a fixed (quota) output.

From the equation 1, it is evident that the profitability change can be decomposed to seven components: (i) the output growth component , (ii) the output price change component , (iii) the input price change component , (iv) the technical change component *TC*, (v) the scale component , (vi) the mark-up component and the technical efficiency change . Kumbhakar and Lien (2009) noted that the scale component is zero if the *RTS* is unity (optimum scale) and that mark-up component is zero if output prices are competitive and marginal cost pricing rule is followed. If the technical change component is positive, the profitability will increase over time, ceteris paribus. The increase of profitability is also caused by a positive technical efficiency change, by output price increase and input price decrease.

The components (i)-(iii) can be computed directly from the observed data according to the following equations based on Sipiläinen et al. (2013):

 (2)

where: (3)

where: is the price of output *m* (*m=1,…,M*), is a quantity of output *m* (*m=1,…,M*), is the price of output *j* (*j=1,…,J*) and is a quantity of input *j* (*j=1,…,J*).

 (4)

 (5)

As Sipiläinen et al. (2013) noted, the employing of averages of the consecutive periods *t-1* and *t* ensure that the analysis is time consistent for ‘static’ variables.

A computation of the rest of components (iv)-(vii) is based on the estimation of cost function.

The cost function estimation needs information about input prices. However, this information is limited and the variability of input price is low for such estimation, we employ the duality theorem and estimate an 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:

 (6)

where: , *α, β, δ* are parameters to be estimated. The symmetry restrictions imply that and . is a stochastic error term and is time varying inefficiency.

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

The equation 6 can be estimated in different ways considering the existence of farm heterogeneity, namely as the true random effects model (TREM) and the true fixed effects model (TFEM). We use the alternative specifications to check robustness of results.

Following Kumbhakar and Lien (2009) the TC component, that take into the account the averages of the consecutive periods *t-1* and *t*, can be computed from IDF as in the equation 7:

 (7)

The returns-to-scale component is computed using following equations 8 - 10:

 (8)

 (9)

 (10)

The equation 10 is used also to compute the mark-up component. Finally, the technical efficiency change is computed using the equation 11:

, (11)

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

The TFEM and the TREM are estimated using the maximum simulated likelihood method in the econometric software LIMDEP 9.0.

The analysis uses an unbalanced panel data set drawn from the FADN database provided by the European Commission. The data covers the period from 2004 to 2011. Information on two types of milk producers are used: specialized milk production covered farms with the share of milk production on the total production higher than 40 % (1,577 cases) and mixed farms (2,642 cases). For estimation of IFD we used following outputs and inputs in this study: milk production in litres (y1), other animal production (y2), plant production (y3), labour measured in AWU (x1), total utilized land in hectares (x2), the cost of feeds for grazing livestock (x3), the costs of other material (x4) and a capital measured as the sum of contract work and depreciation (x5).

The impact of the Common Agriculture Policy is analyzed with the subsidies divided into investment subsidies and other ones (total subsidies excluding on investments). Moreover, we separately analyzed the specific support of milk production, namely dairy premium, subsidies under Article No. 68 and any other subsidies on dairy products (milk subsidies).

The table 1 presents the basic statistic characteristics of above mentioned variables as well as subsidies. These characteristics are presented separately for specialized dairy farms and for mixed farms. The specialized dairy farms are smaller than the mixed ones in the number of workers as well as in the utilized agricultural land. This connected with lower volume of other inputs leads to the lower production of all products per farm. On the other hand, the specialized dairy farms reached higher milk yields (6,313 l/cow) compare to the mixed farms (5,853 l/cow on average). Also the realized price of milk production is slightly higher in specialized dairy farms (0.29 EUR/l compared to 0.28 EUR/l in mixed farms). That is the specialized dairy farms can produce higher quality milk than the mixed farms or have a higher market power.

Both types of farms can be characterized with a high share of rented agricultural land. This share is slightly higher in mixed farms (87 % on average) compare to 77 % in specialized dairy farms. The higher share of paid labour inputs (79 % on average) is typical also for mixed farms. However, the higher share of family workers is more common in the specialized dairy farms (40 %).

Table 1. Characteristics of sample

|  |
| --- |
| SPECIALIZED DAIRY FARMS |
|  | Mean | Std.Deviation | Minimum | Maximum | Cases |
| AWU | 25.7 | 30.2 | 0.8 | 177.6 | 1577 |
| Land [ha] | 671.1 | 728.8 | 1.3 | 5118.3 | 1577 |
| Feeds [€] | 185837 | 223901 | 2218 | 1.32E+06 | 1577 |
| Other material [€] | 158841 | 225817 | 245.3 | 1.42E+06 | 1577 |
| Capital [€] | 121201 | 145981 | 113.8 | 1.11E+06 | 1577 |
| Milk production [l] | 1.43E+06 | 1.72E+06 | 16100 | 1.16E+07 | 1577 |
| Other animal production [€] | 111957 | 157479 | 114.7 | 1.41E+06 | 1577 |
| Plant production [€] | 238191 | 324289 | 806.7 | 2.21E+06 | 1577 |
| Milk subsidies [€] | 5300.7 | 13832.3 | 0 | 89191.4 | 1577 |
| Total subsidies – excluding on investments [€] | 205450 | 227858 | 0 | 1.21E+06 | 1577 |
| Investment subsidies [€] | 10018.9 | 47207.4 | 0 | 608683 | 1577 |
| MIXED FARMS |
|  | Mean | Std.Deviation | Minimum | Maximum | Cases |
| AWU | 48 | 43.1 | 0.7 | 307.9 | 2642 |
| Land [ha] | 1347.6 | 1059 | 6.3 | 7310 | 2642 |
| Feeds [€] | 247200 | 220306 | 531.5 | 1.49E+06 | 2642 |
| Other material [€] | 459186 | 475755 | 366.5 | 3.36E+06 | 2642 |
| Capital [€] | 231749 | 224847 | 131.9 | 1.84E+06 | 2642 |
| Milk production [l] | 1.65E+06 | 1.57E+06 | 400 | 1.20E+07 | 2642 |
| Other animal production [€] | 287112 | 364045 | 4.4 | 4.03E+06 | 2642 |
| Plant production [€] | 718676 | 728817 | 933.2 | 7.28E+06 | 2642 |
| Milk subsidies [€] | 4169.6 | 11856 | 0 | 97810.1 | 2642 |
| Total subsidies – excluding on investments [€] | 348253 | 294693 | 0 | 2.32E+06 | 2642 |
| Investment subsidies [€] | 21028.7 | 90307.7 | 0 | 1.41E+06 | 2642 |

Source: own calculations

Outputs as well as inputs (except for milk production, labour and land) are deflated by price indices (individual output and input indices (2005 = 100) – source EUROSTAT database). The output price for milk and input prices for labour and land are gained from the FADN database. The rest prices are substituted by price indexes gained from the EUROSTAT database.

Results AND DISCUSSION

The table 2 provides the estimated parameters of the IDF for both model specifications. Almost all parameters are significant even at 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, positive linear homogeneity, non decreasing and convex in outputs, and decreasing in inputs. This requirements imply: *xj* > 0 and *ym* < 0 for *j=2,...,5* and *m=1,…,3*. The table 2 shows that these conditions are met.

Table 2. Parameters estimate

|  |  |
| --- | --- |
| TFEM | TREM |
| Variable  | Coeff.  | SE  | P [|z|>Z\*]  | Variable  | Coeff.  | SE  | P [|z|>Z\*]  |
| Time  | 0.0179\*\*\* | 0.0008 | 0.0000 | Time  | 0.0170\*\*\* | 0.0008 | 0.0000 |
| Y1  | -0.3776\*\*\* | 0.0042 | 0.0000 | Y1  | -0.3720\*\*\* | 0.0008 | 0.0000 |
| Y2 | -0.1279\*\*\* | 0.0028 | 0.0000 | Y2 | -0.1166\*\*\* | 0.0033 | 0.0000 |
| Y3 | -0.4378\*\*\* | 0.0050 | 0.0000 | Y3 | -0.4000\*\*\* | 0.0029 | 0.0000 |
| X2  | 0.2983\*\*\* | 0.0049 | 0.0000 | X2  | 0.3275\*\*\* | 0.0057 | 0.0000 |
| X3  | 0.2587\*\*\* | 0.0051 | 0.0000 | X3  | 0.2528\*\*\* | 0.0045 | 0.0000 |
| X4  | 0.1968\*\*\* | 0.0053 | 0.0000 | X4  | 0.1670\*\*\* | 0.0045 | 0.0000 |
| X5  | 0.0350\*\*\* | 0.0033 | 0.0000 | X5  | 0.0383\*\*\* | 0.0035 | 0.0000 |
| TT  | 0.0021\*\*\* | 0.0007 | 0.0000 | TT  | 0.0072\*\*\* | 0.0008 | 0.0000 |
| Y1T  | -0.0056\*\*\* | 0.0011 | 0.0000 | Y1T  | -0.0044\*\*\* | 0.0011 | 0.0001 |
| Y2T | 0.0059\*\*\* | 0.0085 | 0.0000 | Y2T | 0.0051\*\*\* | 0.0008 | 0.0000 |
| Y3T  | 0.0027\*\* | 0.0012 | 0.0203 | Y3T  | 0.0034\*\*\* | 0.0012 | 0.0043 |
| Y11 | -0.1319\*\*\* | 0.0028 | 0.0000 | Y11  | -0.1243\*\*\* | 0.0025 | 0.0000 |
| Y22  | -0.0734\*\*\* | 0.0022 | 0.0000 | Y22  | -0.0673\*\*\* | 0.0017 | 0.0000 |
| Y33  | -0.1339\*\*\* | 0.0052 | 0.0000 | Y33  | -0.1052\*\*\* | 0.0037 | 0.0000 |
| Y12  | 0.0122\*\*\* | 0.0024 | 0.0000 | Y12  | 0.0137\*\*\* | 0.0019 | 0.0000 |
| Y13 | 0.0759\*\*\* | 0.0036 | 0.0000 | Y13 | 0.0762\*\*\* | 0.0031 | 0.0000 |
| Y23 | 0.0632\*\*\* | 0.0028 | 0.0000 | Y23 | 0.0503\*\*\* | 0.0022 | 0.0000 |
| X2T  | -0.0109\*\*\* | 0.0021 | 0.0000 | X2T  | -0.0088\*\*\* | 0.0022 | 0.0001 |
| X3T  | 0.0158\*\*\* | 0.0017 | 0.0000 | X3T  | 0.0161\*\*\* | 0.0018 | 0.0000 |
| X4T  | -0.0030\*\* | 0.0015 | 0.0409 | X4T  | -0.0051\*\*\* | 0.0014 | 0.0003 |
| X5T  | 0.0017 | 0.0014 | 0.1980 | X5T  | 0.0024\* | 0.0013 | 0.0619 |
| X22  | 0.0541\*\*\* | 0.0122 | 0.0000 | X22  | 0.0364\*\*\* | 0.0122 | 0.0029 |
| X33  | 0.0771\*\*\* | 0.0096 | 0.0000 | X33  | 0.1164\*\*\* | 0.0092 | 0.0000 |
| X44  | 0.0614\*\*\* | 0.0059 | 0.0000 | X44  | 0.0439\*\*\* | 0.0052 | 0.0000 |
| X55  | 0.0202\*\*\* | 0.0047 | 0.0000 | X55  | 0.0260\*\*\* | 0.0493 | 0.0000 |
| X23  | 0.01892\* | 0.0102 | 0.0624 | X23  | 0.0146 | 0.0103 | 0.1559 |
| X24 | 0.0068 | 0.0072 | 0.3493 | X24 | 0.0579\*\*\* | 0.0064 | 0.0000 |
| X25 | -0.0072 | 0.0060 | 0.2248 | X25 | -0.0228\*\*\* | 0.0063 | 0.0003 |
| X34 | -0.0592\*\*\* | 0.0067 | 0.0000 | X34 | -0.0923\*\*\* | 0.0060 | 0.0000 |
| X35 | -0.0295\*\*\* | 0.0054 | 0.0000 | X35 | -0.0227\*\*\* | 0.0058 | 0.0001 |
| X45 | -0.0078\* | 0.0045 | 0.0839 | X45 | -0.0013 | 0.0046 | 0.7778 |
| Y1X2 | 0.0033 | 0.0060 | 0.5867 | Y1X2 | 0.0172\*\*\* | 0.0055 | 0.0019 |
| Y1X3 | 0.0252\*\*\* | 0.0048 | 0.0000 | Y1X3 | 0.0069 | 0.0043 | 0.1143 |
| Y1X4 | 0.0024 | 0.0038 | 0.5316 | Y1X4 | -0.0013 | 0.0036 | 0.7212 |
| Y1X5 | 0.0109\*\*\* | 0.0033 | 0.0009 | Y1X5 | 0.0092\*\*\* | 0.0032 | 0.0040 |
| Y2X2 | -0.0103\*\* | 0.0052 | 0.0475 | Y2X2 | -0.0221\*\*\* | 0.0049 | 0.0000 |
| Y2X3 | 0.0165\*\*\* | 0.0039 | 0.0000 | Y2X3 | 0.0231\*\*\* | 0.0034 | 0.0000 |
| Y2X4 | -0.0194\*\*\* | 0.0036 | 0.0000 | Y2X4 | -0.0035 | 0.0028 | 0.2117 |
| Y2X5 | -0.0146\*\*\* | 0.0030 | 0.0000 | Y2X5 | -0.0165\*\*\* | 0.0026 | 0.0000 |
| Y3X2 | -0.0141\*\* | 0.0066 | 0.0311 | Y3X2 | 0.0057 | 0.0064 | 0.3653 |
| Y3X3 | -0.0367\*\*\* | 0.0059 | 0.0000 | Y3X3 | -0.0235\*\*\* | 0.0048 | 0.0000 |
| Y3X4 | 0.0150\*\*\* | 0.0050 | 0.0028 | Y3X4 | 0.0072\* | 0.0043 | 0.0915 |
| Y3X5 | 0.0079\* | 0.0041 | 0.0536 | Y3X5 | 0.0111\*\*\* | 0.0040 | 0.0051 |
|  |  |  |  | Const. | 0.1046\*\*\* | 0.0047 | 0.0000 |
|  |  |  |  | Scale par. for constant | 0.2483\*\*\* | 0.0024 | 0.0000 |
| Sigma  | 0.4352\*\*\* | 0.0037 | 0.0000 | Sigma  |   0.1376\*\*\* | 0.0026  | 0.0000   |
| Lambda  | 3.7679\*\*\* | 0.0942 | 0.0000 | Lambda  |   1.4252\*\*\* | 0.0908   | 0.0000   |

Source: own calculations

Note: \*\*\*, \*\*, \* denotes significance at the 1%, 5%, and 10% levels respectively

Since all variables are normalised in logarithm by their sample mean, the first-order parameters can be interpreted as elasticity of the IDF with respect to output and as shadow value share with respect to inputs on the sample mean. There are some common features of the IDF elasticities in both model specifications: the input share of capital is the lowest (0.035-0.038), the input share of land is the highest (0.298-0.328), elasticity of the milk yield is about 0.372-0.378 and is lower than the elasticity of the plant outputs (0.400-0.438). That is, the share of capital on the total cost is only 4 %, however, the share of land is about 30 %. This reflects the high share of rented land and also the absence of innovations in the milk production connected with capital market imperfections especially at the beginning of analyzed time period. This result confirms also Čechura et al. (2014).

The parameter lambda is highly significant and higher than one in both model specifications. That is the variation in *uit* is more pronounced than the variation in the random component *vit*. That indicates that most of the deviation from the border of the input requirement set is due to technical inefficiencies rather than random shocks.

The comparison of both model specifications leads to differences in technical efficiency estimate. The TREM gives significantly higher technical efficiency with lower variability. The average technical efficiency based on the TREM of specialized dairy farms is 91.26 % with standard deviation on the level 4 %. However, it is only 77.96 % (with 8 % standard deviation) when the TFEM is employed. This result holds also for mixed farms. According to Čechura (2010), this difference can be caused by the incidental parameter problem, due to the short and unbalanced panel dataset and the large number of farms that caused inconsistency of lots of fixed effects.

When we compared average technical efficiencies of specialized and mixed farms, we can conclude that specialized dairy farms are almost the same technical efficient as mixed farms, whose average technical efficiency is 78.68 % based on the TFEM and 91.25 % based on the TREM. These results can be also compared with the results of Čechura et al. (2014) who used the Fixed Management Model (FMM) to analyze technical efficiency of Czech and Slovak farms producing milk. The technical efficiency quantified on the base of the FMM was slightly higher than on the base of the TREM (92%). That is, the milk producers highly exploit their production possibilities and their efficiency does not depend on the level of specialization.

The table 3 presents the components of profitability in both types of farms based on the both model specifications. The output growth component (OUTPUTG) was, on average, negative in specialized (-0.30 % per annum) as well as mixed (-0.43 %) farms. This low output average decrease can be explained by the milk quota regulation which fulfillment was difficult in the first year of its implementation and also by the structural change of the Czech agrarian sector. The graphs 1 and 2 show that the decrease of output was more pronounced in mixed farms than in the specialized ones.

The output price change component (PRICEG) was found to be positive and slightly higher in specialized dairy farms (1.97 %) than in mixed farms (1.59 % per annum). The output price change negatively affected the profitability of both types of farms only in 2005 and 2009 when the significant decrease of milk price can be found on the world commodity market.

The input price change component (WG) negatively affected the profitability (see the equation 1). This effect was more pronounced in specialized dairy farms (-1.25 % per annum). Because these farms used less rented land and paid labours, we can supposed that the negative impact of input price had base in the increase of purchased feed. The negative influence of input prices was especially pronounced in the years 2007, 2008, 2010 and 2011.

The technical change component as well as the technical efficiency change component was sensitive to the model specification as can be seen from the table 3. The technical change component (TCREM in graphs 1 and 2) contributed positively to the profitability change and more significantly in the mixed farms than in the specialized dairy farms. This component is also more pronounced when the TREM is employed. The technical progress was accelerated by the investment subsidies, especially in the years 2005, 2010 and 2011 when the volume of obtain subsidies significantly increased compared to the previous years. The changes of investment subsidies (INVSCH) are also presented in the graphs 1 and 2.

Table 3. Calculated profitability change components (in percent)

|  |
| --- |
| SPECIALIZED DAIRY FARMS |
|  | TFEM | TREM |
| Components | Mean | Std.Deviation | Mean | Std.Deviation |
| Output growth | -0.2972 | 15.4414 | -0.2972 | 15.4414 |
| Output price change | 1.9682 | 18.6845 | 1.9682 | 18.6845 |
| Input price change | 1.2520 | 9.9545 | 1.2520 | 9.9545 |
| Technical change | 0.5812 | 0.8669 | 3.1549 | 1.4784 |
| Scale | 0.0598 | 2.0959 | 0.0251 | 2.5413 |
| Mark-up | 2.0817 | 6.6187 | 2.0783 | 6.5570 |
| Technical efficiency change | 0.0732 | 15.6723 | -0.1073 | 6.7269 |
| Profitability change | 2.6946 | 21.7337 | 5.0906 | 19.0364 |
| MIXED FARMS |
|  | TFEM | TREM |
| Components | Mean | Std.Deviation | Mean | Std.Deviation |
| Output growth | -0.4266 | 12.2853 | -0.4266 | 12.2853 |
| Output price change | 1.5921 | 12.8097 | 1.5921 | 12.8097 |
| Input price change | 0.4535 | 10.3547 | 0.4535 | 10.3547 |
| Technical change | 0.7455 | 0.9438 | 3.3630 | 1.5515 |
| Scale | -0.1553 | 2.6589 | -0.2392 | 3.0730 |
| Mark-up | 2.4528 | 7.9073 | 2.3979 | 7.8108 |
| Technical efficiency change | -0.8055 | 14.3295 | -0.3676 | 6.5538 |
| Profitability change | 2.5125 | 18.6038 | 5.6420 | 16.2999 |

Source: own calculations

The scale component (RESC) was also more pronounced in the mixed farms than in the specialized ones, where its value was closed to zero. However, the average RTS were higher than 1 (1.06-TFEM, 1.11-TREM). That indicates the presence of increasing RTS at the mean of specialized dairy farms sample. This result implies that the farms have not exploited scale economies entirely. The increasing RTS was found also in mixed farms (1.07-TFEM, 1.14-TREM).

The mark-up component (REMUP) contributed positively in both types of farms. However, it was slightly more pronounced in mixed farms. The non-zero mark-up component implies that there exist some market imperfections on the commodity market. This non-competitiveness is highly pronounced in all analyzed time period, see the graphs 1 and 2.

The technical efficiency change (RETE) contributed negatively to the profitability change in the mixed farms and in the specialized dairy farms when the TREM is employed. It means, that on average the milk producers especially the mixed farms were falling behind to the technical frontier over time. The contribution of this component in specialized dairy farms based on the TFEM is positive, on average, however, it is closed to zero. According to Čechura (2010), we consider the results of the TREM to be more valid than the technical efficiency estimates based on the TFEM due to the previously mentioned incidental parameter problems. Therefore, we analyze the development of profitability and its components and the relationship among the profitability change and agricultural policy change based on the TREM (see the graph 1 and 2, and the table 4).

Finally, the overall increase in profitability was slightly higher in the mixed farms (5.64 %) than in the specialized dairy farms (5.09 % per annum on the base of the TREM). Moreover, the profitability change was less volatile in the mixed farms. The significant negative profitability change was recognized in the year 2009 in both types of farms, similarly to Doucha et al. (2012). However, the decrease of profitability was more pronounced in the specialized dairy farms. The reason for mentioned decrease can be especially found out in the crises on the EU commodity market which press down the output prices and subsequently the milk production. The following years can be characterized by the profitability increase. This can be also the result of milk subsidies, which significantly increased due to the Article No. 68 and the national government regulation No. 87/2010.

Graph 1. Profitability development – specialized farms

Source: own calculations

Graph 2. Profitability development – mixed farms

Source: own calculations

The graphs 1 and 2 presented also the change of total subsidies excluding subsidies on investments (TSUBEXI). The correlations among this subsidy change, as well as investment subsidy change, and the profitability change and its components are presented in the table 4.

Investment subsidies are positively correlated with the technical change in almost all analyzed time periods, the year 2010 is the exception. On the other hand, the technical change is positively correlated also with other subsidies and even with the higher correlation coefficient. The significant positive relationship can be found also between operation subsidies change and the technical efficiency change. This positive, nonetheless low, correlation between the technical efficiency change and subsidies change is especially due to the decrease of both variables. That is, we cannot conclude that the operation subsidies positively contributed to the technical efficiency of milk producers. Moreover, the result of Latruffe et al. (2008) and Rizov et al. (2013) shows that a public support received by Czech dairy farms reduced their technical efficiency.

The significant relationship can be found also among the operation subsidies change, the output price change and the mark-up component. This correlation coefficients gained negative values in 2008 and 2011. That is, this support slightly eliminated the market power on commodity market. The operation subsidies are the supplementary income to the revenue from sold products which allows producers to release their pressure in the price negotiations. The operation subsidies change is negatively correlated with the input price change. This can be explained by the transfer of a part of the gained volume of subsidy to the input owners. The correlation among operation subsidies and output growth is very low. Because decoupled payments have the major part of this measure, we can conclude that the production effect of decoupled payment is negligible, similar to Henningesen at el. (2009).

Table 4. Pearson’s correlation coefficients – specialized dairy farms (TREM)

|  |
| --- |
| Total subsidies (excluding subsidies on investments) change |
| Components | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
| Output growth | -0.260\*\*\* | 0.116\* | 0.092\* | 0.001 | 0.025 | 0.178\*\* | -0.100\* 00 |
| Output price change | 0.155\*\* | -0.262\*\*\* | -0.562\*\*\* | -0.326\*\*\* | 0.633\*\*\* | -0.524\*\*\* | -0.514\*\*\* |
| Input price change | -0.130\*\* | -0.135\*\*\* | -0.400\*\*\* | -0.037 | -0.233\*\*\* | -0.025 | -0.295\*\*\* |
| Technical change | 0.509\*\*\* | 0.511\*\*\* | 0.515\*\*\* | 0.398\*\*\* | 0.285\*\*\* | 0.342\*\*\* | 0.406\*\*\* |
| Scale | -0.077 | 0.032 | -0.177\*\* | 0.244\*\*\* | -0.126\* | -0.052 | 0.230\*\*\* |
| Mark-up | -0.001 | -0.004 | -0.113 | -0.264\*\*\* | 0.040 | 0.024 | -0.195\*\*\* |
| Technical efficiency change | 0.112 | 0.049 | -0.075 | 0.165\*\* | 0.158\*\* | -0.082 | 0.126\* |
| Profitability change | -0.025 | 0.141 | -0.037 | -0.119 | 0.463\*\*\* | -0.183\*\* | -0.215\*\*\* |
| Investment subsidies change |
| Components | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
| Output growth | -0.068 | 0.054 | -0.047 | 0.005 | -0.080 | 0.071 | 0.014 |
| Output price change | -0.006 | -0.074 | -0.066 | -0.119\* | 0.120\*\* | -0.149\*\* | -0.052 |
| Input price change | -0.008 | 0.047 | 0.014 | 0.052 | 0.029 | -0.007 | -0.078 |
| Technical change | 0.181\*\*\* | 0.254\*\* | 0.165\*\*\* | 0.255\*\* | 0.134\* | 0.089 | 0.142\* |
| Scale | -0.003 | -0.033 | 0.043 | 0.077 | 0.010 | -0.008 | 0.050 |
| Mark-up | 0.005 | 0.030 | -0.016 | -0.074 | 0.079 | -0.020 | -0.029 |
| Technical efficiency change | 0.055 | -0.047 | -0.004 | 0.059 | 0.082 | -0.070 | -0.018 |
| Profitability change | -0.020 | -0.007 | -0.054 | -0.052 | 0.054 | -0.075 | 0.005 |

Source: own calculations

Note: \*\*\*, \*\*, \* denotes significance at the 1%, 5%, and 10% levels respectively

Conclusion

This section summaries the results and discusses them in the light of the research questions asked in the introduction. The milk production in the Czech Republic is realized in specialized dairy farms as well as in mixed farms which produce also other animal outputs or plant products. These two types of farms differs in size as well as in the share of rented inputs (land and labour), however, the efficiency of input using is almost the same in both types. The level of technical efficiency shows that milk producers highly exploit their production possibilities. However, technical efficiency is not the most important determinant of profitability. The price changes significantly more influenced the profitability change than the technical efficiency in the analyzed time period. On average, the profitability change was positive in this time and slightly lower in the specialized dairy farms than in the mixed farms. The output price change, the technical change and mark-up components positively influenced the mentioned profitability change in both types of farms. On the other hand, output growth, the input price change and the technical efficiency change components had negative effects on profitability growth. Some of these components were influenced by the agricultural policy change. The implementation of milk quotas in the Czech Republic caused the output decrease in the initial period. However, the other instruments like the investment support and the operation support have positive impact on the technical change. The operation support also affected the mark-up, the output price and the input price change component due to elimination of market power on commodity market and due to partial shifts to input owners. On the other hand, the production effect of decoupled payment is negligible. These conclusions are important for the evaluation of the effectiveness of the Common Agriculture Policy.

**Acknowledgements**

The research was conducted as part of the internal grant of the Czech University of Life Sciences Prague - IGA 20151015: ‘Profitability of Czech agricultural businesses with milk production specialization in the context of agricultural policy changes’.

REFERENCES

BOŠKOVÁ, I. (2014): Collaboration in the Czech Dairy Chain. *Agris on-line Papers in Economics and Informatics*, 5(4): 35-45.

COELLI, T., SINGH, S., FLEMING, E. (2003): An input distance function approach to the measurement of technical and allocative efficiency: with application to Indian dairy processing plants [on-line]. [cit. 2015-03-15] URL: https://editorialexpress.com/cgi-bin/conference/download.cgi?db\_name=esam2003&paper\_id=105.

ČECHURA, L., HOCKMAN, H., MALÁ, Z., MALÝ, M. (2014): Productivity and efficiency differences between Czech and Slovak milk producers. *Review of Agricultural and Applied Economics*, 2: 17-21.

ČECHURA, L. (2010): Estimation of technical efficiency in Czech agriculture with respect to firm heterogeneity. *Agriculture Economics - Czech*, 56(4): 183-191.

DOUCHA, T., FOLTÝN, I., HUMPÁL, J. (2012): Profitability of dairy and suckler cows breeding on Czech farms. *Agricultural Economics-Czech*, 58 (9): 397-408.

FRELICH, J., ŠLACHTA, M., STŘELEČEK, F., LOSOSOVÁ, J. (2011): Profitability of dairy farming in relation to the type of feeding system. *Journal of Agrobiology*, 28(1): 55-59.

FOLTÝN, I., KOPEČEK, P., ZEDNÍČKOVÁ, I., VÁVRA, V. (2009): Profitability development of key agricultural commodities in 2002–2006. *Agricultural Economics-Czech*, 55: 181–199.

HENNINGSEN, A., KUMBHAKAR, S., LIEN, G. (2009): Econometric Analysis of the Effects of Subsidies on Farm Production in Case of Endogenous Input Quantities. In AAEA & ACCI Joint Annual Meeting, Milwaukee, Wisconsin, July 26-29, 2009.

JONDROW, J., LOVELL, C. A., MATEROV, I. S., SCHMIDT, P. (1982): On the estimation of technical inefficiency in stochastic frontier production function model. *Journal of Econometrics*, 86: 1044-1057.

KUMBHAKAR, S.C., LIEN, G. (2009): Productivity and profitability decomposition: a parametric distance function approach. *Food Economics*, 6: 143-155.

LOVELL, C. A. K., RICHARDSON, S., TRAVERS, P., WOOD, L. L. (1994): Resources and Functionings: A New View of Inequality in Austria. IN EICHHORN W.: *Models and Measurement of Welfare and Inequality.* Berlin, Heidelberg, New York: Springer-Verlag, 787-807.

Latruffe, L., Bakucs, L., Bojnec, S., Ferto, I., Fogarasi, J., Gavrilescu, C., Jelinek, L., Luca, L., Medonos, T., Toma, C. (2008): Impact of public subsidies on farms’ technical efficiency in New Member States before and after EU accession. In the 12th Congress of the European Association of Agricultural Economists – EAAE 2008.

PERNÝ, A., KUBÍČKOVÁ, L. (2011) Method of evaluating the success of the dairy Czech small and medium–sized enterprises. *Universitatis Agriculturea et Silviculturea Mendeliane Brunensis*, 59: 221-230.

RIZOV, M., POKRIVCAK, J., CIAIAN, P. (2013): CAP Subsidies and Productivity of EU farms. *Journal of Agricultural Economics*, 64 (3), p. 537-557.

SIPILÄINEN, T., KUMBHAKAR, S. C., LIEN, G. (2014): Perfotmance of dairy farms in Finland and Norway from 1991 to 2008. *European Review of Agricultural Economics*, 41 (1): 63-86.

SVOBODA, J., NOVOTNÁ, M. (2011): Multifactor productivity analysis in the sample of agricultural enterprises. *Acta Universitatis Agriculturea et Silviculturea Mendeliane Brunensis*, LIX (7): 42-402.

ŠPIČKA, J., SMUTKA, L. (2014): The Technical Efficiency of Specialised Milk Farms: A Regional View [Online]. *Scientific World Journal*, [Cit. 01-01-2015] URL: <http://dx.doi.org/10.1155/2014/985149>.

**Contact address:**

Ing. Zdenka Zakova Kroupova, Ph.D., Czech University of Life Sciences Prague, Kamýcká 129, 165 21 Prague 6, Czech Republic

e-mail: kroupovaz@pef.czu.cz

|  |  |
| --- | --- |
|  |  |
|  |  |